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THE ADVANCED RESEARCH PROJECTS AGENCY, 19[illegible]-19[illegible]

A Study Prepared
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PREFACE

This "historical evaluation" of the Advanced Research Projects Agency (ARPA) as an R&D management institution was commissioned by ARPA in recognition of the fact that remarkably little in the way of an official record or institutional memory had been established during its seventeen year lifetime. From Agency Directors to program managers, the turnover in its leadership has been rapid by most bureaucratic standards, thus eroding first hand knowledge of ARPA's role and activities rather quickly. Conceived as a unique management organization chartered to concentrate on "advanced research" within the Department of Defense, this very uniqueness has frequently been questioned. Virtually every ARPA Director, and most ARPA personnel at all levels, have encountered friendly and not-so-friendly "why ARPA?" and "what is ARPA?" questions throughout its history. This report seeks to explain some of the "whys" and "whats."

For the most part, the study ends in 1972 when ARPA was designated a Defense Agency. This date was arbitrarily chosen. In instances where events or programs started in earlier periods extend beyond 1972, they have been pursued a bit further for sake of completeness, but not past 1974. In particular, no attempt has been made to describe currently active ARPA projects in any detail. Readers interested in such information are referred to the extensive ARPA Congressional testimony and supplementary submissions in recent years.

Although this study does not purport to be a strictly chronological day-by-day sort of history, it has been necessary to include a substantial amount of such descriptive information because in many instances no ready reference material exists and the reader simply must have the information if events are to be understood. It should also be noted this this study is not, nor was it intended to be, an independent technical assessment of the scientific content of ARPA work in particular fields of research.

While every attempt has been made to be comprehensive as to major developments in ARPA's history, some events undoubtedly have been missed or barely touched upon. Others may be treated here in distorted or even incorrect fashion despite best efforts to be accurate. Such errors are unavoidable given the incomplete record available for use. Corrective material will be welcomed.

The range of activities that ARPA has been involved in since 1958 is truly staggering. Discussion of individual programs or projects alone could easily match or exceed the length of this volume; indeed, a few such reports exist. Nor was it possible to cover all the programs. The sample selected is believed to represent a reasonable profile. Apologies are offered in advance to those who feel that something significant has been omitted or dealt with in too cursory a fashion.

The research effort has included rigorous examination of ARPA files and records, other Federal agency files, published literature, and interviews and discussions with key individuals who have worked in ARPA over the years or who have been connected with it. Since there are immense gaps in the Agency's files, especially up to 1967, and only spotty coverage in the records of other agencies and in the open literature, this work relies very heavily on discussions with ARPA Directors, Deputy Directors, Chief Scientists, office directors, and program managers, and other informed persons.

In particular, all of the surviving Directors of ARPA (the first, Roy W. Johnson, is dead) gave unstintingly of their time and made major contributions to the research. A special word of thanks is also owed to Dr. James R. Killian, Jr.,; Dr. Herbert F. York; Admiral John E. Clark, USN (Ret.); Mr. L. P. Gise; Mr. William H. Godel; Brigadier General C. M. Young, Jr. USA (Ret.), and Colonel Dent Lay, USAF (Ret.) for their assistance in reconstructing the events surrounding the creation of ARPA and its early months of operation.

The report is organized generally on the basis of chronological periods which reflect important changes in ARPA's evolution. The "break points" are relatively easy to identify and follow. Most of them coincide with the tenures of particular Directors of ARPA; all rather faithfully reflect the broader organizational and policy setting within which ARPA has functioned.

Use of underlined words or phrases in quotations taken from interviews are intended to reflect emphases made by the speakers. Source footnotes are placed at the end of each chapter for ease of reference.

The report was prepared under the direction of Lee W. Huff and Richard G. Sharp. Approximately two and one-half man years of effort were provided for the research.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

TABLE OF FIGURES

CHAPTER I

ARPA: PERSPECTIVE AND SETTING

OVERVIEW

The Advanced Research Projects Agency (ARPA) of the Department of Defense was seventeen years old in 1975. This chronological period spans a number of pronounced ups and downs, including both first hand relationships with Presidents and serious threats to the Agency's continued existence. ARPA's story is an amalgam of choices of its own making, pressures exerted on it within the DOD, and the influence of broader external forces. As is so often the case, the "broader" the force, the less its impact is recognized by those caught up in the day-to-day problems of running a particular project, program or agency. Accordingly a serious attempt is made throughout this report to relate ARPA's actions and activities to the changing environments within which it has operated. To place ARPA in context quickly, this chapter presents four snapshot views of the Agency and its surroundings: (1) its general budget history, (2) the general R&D environment in the United States and ARPA's relationship to it, (3) ARPA's leadership profile, and (4) an overview of the Agency as developed in this report.

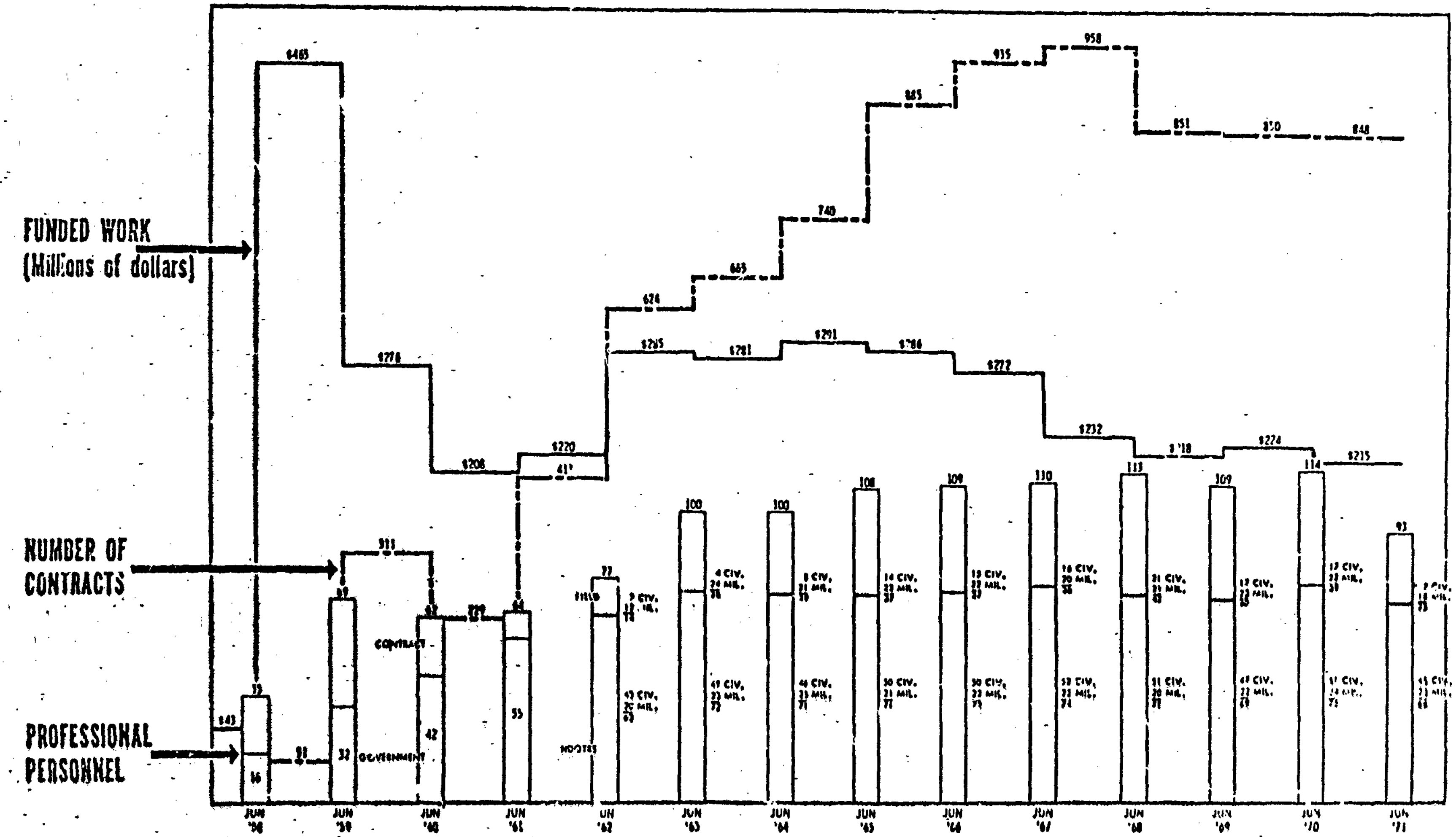
Budgetary/Administrative History

A capsule history of the ARPA budget, along with trends in contracts and professional personnel levels, is shown in Figure I-1. Begun in an atmosphere of urgency in February 1958, the Agency was carried through the end of Fiscal Year 1958 with a small budget primarily drawn from DOD Emergency Funds though it gained immediate supervisory control over a considerably larger program for which funds had already been programmed in existing Service budgets. With the beginning of FY 1959 some of these programs and others, dominated by civilian and military space projects, were incorporated into the ARPA budget. The FY 1959 budget -- the highest in ARPA's history -- was half a billion dollars. Over the next two years most of the space projects were transferred to NASA and the Services, thereby reducing the ARPA budget to just over $200 million by FY 1961. The residual program, a multi-faceted advanced research effort with ballistic missile defense research as its most prominant task, rose to nearly $300 million in the mid-1960's, then declined to a level just over $200 million in the early 1970's. Since about 1968, total budgetary levels have been relatively stable, remaining at approximately $200 million as late as FY 1976. All of the figures, of course, are given in current dollars. It is obvious then that the ARPA budget in real or constant dollars has fallen even more over time.

Figure I-1

ARPA PREPARED BUDGET/ADMINISTRATIVE HISTORY TABLE

ARPA HISTORY SUMMARY



Update to table: Data are not maintained by ARPA in exactly the form presented above for years after FY 1971. Contracts from FY 1972 - FY 1975 are estimated to number approximately 850. Year-end budgets, following Congressional cuts and adjustments, were $212 million in FY72, $200 million in FY73, $194 million in FY74, and $202 million in FY75 (these data vary slightly from the "Funded Work" category presented in the Figure). Professional personnel figures were FY 1972 - 95, FY 1973 - 98, FY 1974 - 101, and FY 1975 - 108, with approximately 25 field personnel and 70-75 headquarters staff each year.

In terms of professional personnel, ARPA developed a headquarters staff of approximately seventy persons by June 1959, and rarely deviated from this level in subsequent years. In the mid-1960's additional staff professionals were required for overseas operations, notably in Southeast Asia, but the total number of staff positions has seldom exceeded one hundred. Of this relatively small number, perhaps only about fifty on the average have had substantive project management responsibilities -- each such individual thus being responsible for perhaps $4-5 million of research annually. Reliance on Service executive agents to provide procurement and detailed technical review services has contributed to ARPA's low manning levels.

A final summary characteristic of ARPA's workload is that the number of contracts supported grew steadily throughout the early- to mid-1960's before dropping slightly and then stabilizing in 1968. The growth in numbers of contracts reflects both increases in funding in the early 1960's and a shift of emphasis away from larger-scale development projects (such as were contained in the space, ballistic missile defense and nuclear test detection projects) to more small-scale contracts.

The overall picture of ARPA, aside from its very abrupt creation and rapid acquisition and brief management of space-related programs 1958-1959, is one of rather gradual evolution with a stabilization in the mid- to late-1960's, followed by some significant changes in program mix about 1969-1970 and a "settling in" at a budget level near the $200 million mark.

The General R&D Environment

ARPA's research and development budget, and its history in general, have been greatly affected by the external forces that have influenced total U. S. R&D effort over the years, particularly that segment of R&D related to national security and international competition. ARPA's development occurred during the great boom in R&D expenditures in the early 1960's and the cessation of its growth in the mid-1960's corresponds closely to the slow-down in national R&D funding which took place at that time. In a broader sense, national trends in R&D have contributed greatly to the atmosphere in which ARPA work has been conducted through the years.

To illustrate, Figure I-2* presents a long-term view of development in federal R&D funding over a 34 year period. As can be seen, there were

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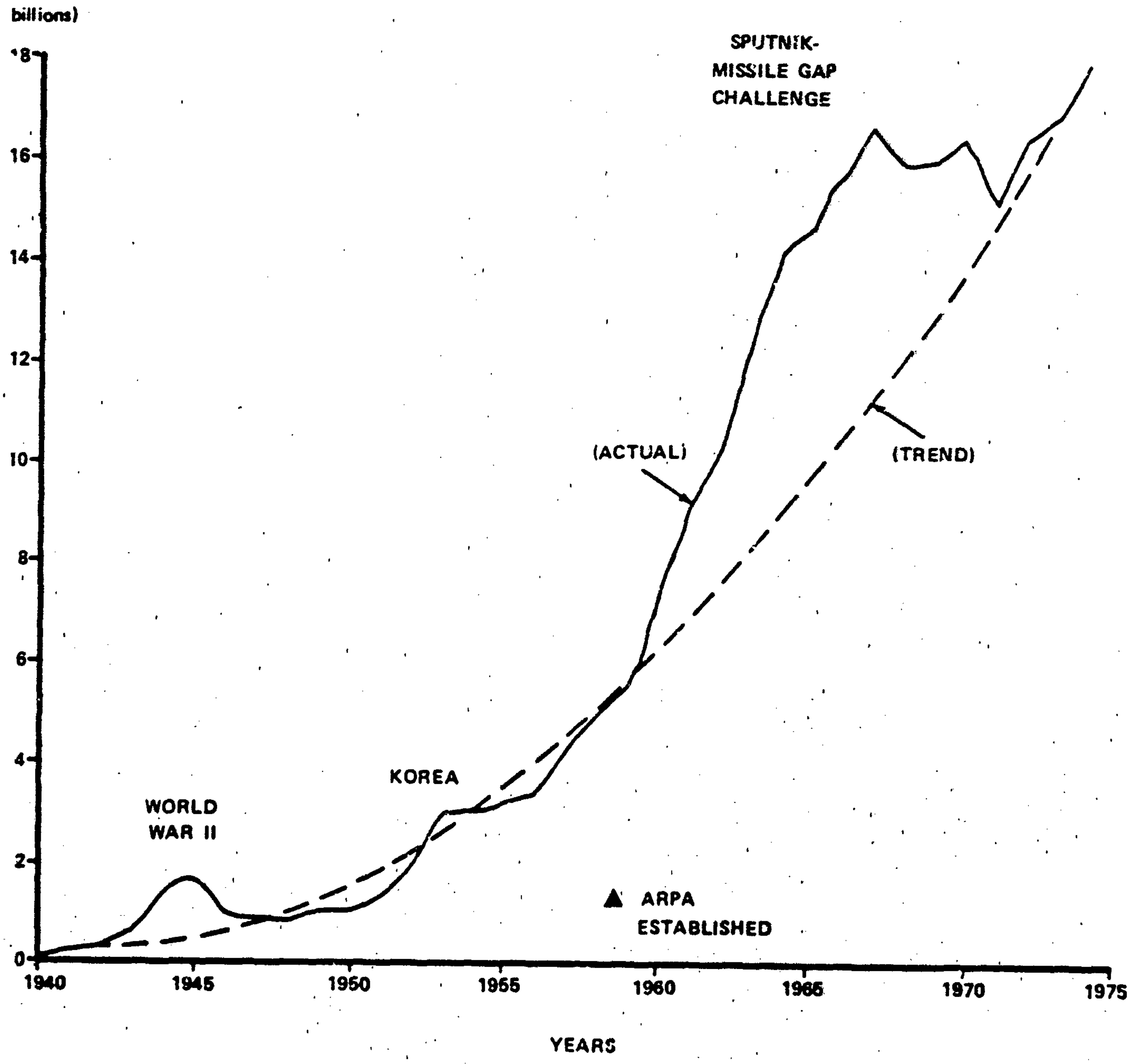
* This and the following four figures are derived from the following sources: (1) National Science Foundation, National Patterns of R&D Resources, 1953-73, NSF 74-303; (2) National Science Foundation, Federal Funds for Research, Development and Other Scientific Activities, Fiscal Years 1972, 1973 and 1974, Volume XXII, NSF 74-900, and previous volumes of the same publication; (3) Special Analyses, Budget of the United States Government; and (4) ARPA budget data presented to the House Appropriations Committee over the period covered.

FIGURE I–2

TOTAL ANNUAL FEDERAL R & D OBLIGATIONS: 1940–1974



three periods of national crisis during which R&D funding grew at a more substantial rate than could be supported over the long term: World War II, the Korean War and the post-Sputnik period. ARPA was created precisely at the beginning of this latter period and Figure I-2 illustrates what an exceptional era that was. The acceleration in R&D spending in that period was both sharper and more sustained than during the two wartime periods and it stimulated an outlook on the future of R&D, and its role in defense and other government activities, which greatly conditioned the behavior of federal agencies.

The special mid-1960's set of attitudes towards the role and importance of R&D is well illustrated by a 1968 OECD study of science policy in the United States.[1] An objective, in-depth study by foreign observers, it is nonetheless highly colored by optimism about the function and anticipated performance of R&D in industrialized countries. The fact that U. S. R&D expenditures in this period reached three per cent of GNP, for example, is treated as a desirable threshold level which once passed would continue to be exceeded. This three per cent figure became both a sumbol of progress and a target for other countries. In fact, however, the R&D component of U. S. GNP had dropped from three per cent in the mid-1960's to 2.3 per cent in 1973 and shows no sign of rising substantially. Thus OECD's "magic" three per cent figure was extremely shortlived.*

As a further example of the optimism of the 1960's, the OECD cited, as an alleged conservative estimate of future growth of R&D through 1980, a McGraw Hill survey forecasting a slowing down of R&D growth rates, with expenditures anticipated to reach a level of $46 billion in 1980.[2] The actual decline in R&D growth has been much sharper. In 1972, for instance, R&D expenditures totalled only $28 billion and were growing at a 4 per cent annual rate, roughly equivalent to growth in GNP. If these rates continued R&D would total only $38 billion by 1980.

Many other distinguishing features of U. S. R&D in the heyday of the mid-1960's have also changed. In 1965, for instance, 64 per cent of U. S. R&D was supported by public funds, a figure exceeding France (63%), the United Kingdom (57%), Sweden (48%), and numerous other countries with lower support levels. By 1972, however, U. S. public support had dropped to 54 per cent.[3] Similarly, in the mid-1960's 60 per cent of

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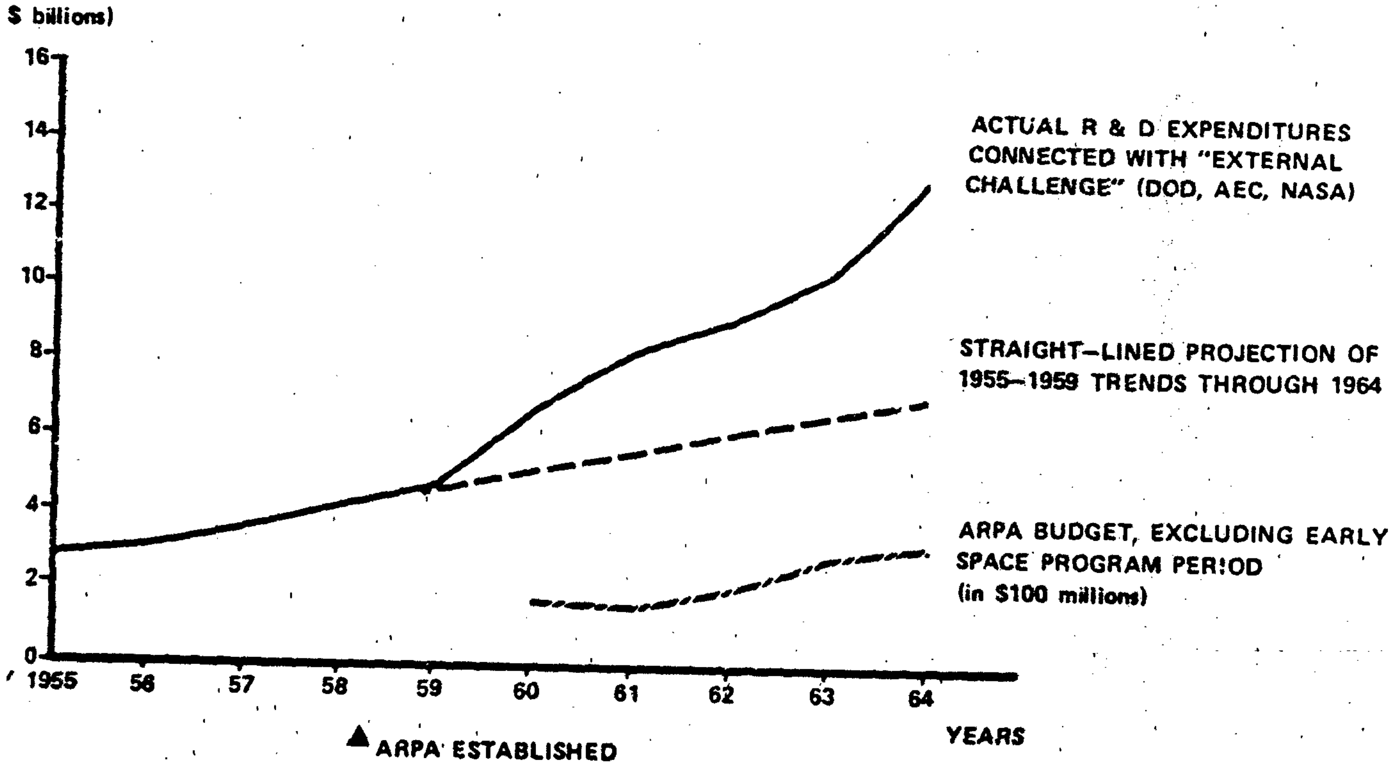
* According to the latest OECD calculations, U. S. R&D spending is 2.2 per cent of total public and private "yearly expenditures," a term which is equivalent to GNP. The U. S. is the only country to have reached as high as 2.5 per cent in the last decade. Germany now has the highest rate, 2.3 per cent. Slightly reminiscent of themes common in the 1950's, OECD notes "the disturbing possibility ... that the real science potential of some OECD member countries may be declining." (Cited in Wall Street Journal, October 13, 1975.)

FIGURE I–3

SELECTED R & D EXPENDITURES, ACTUAL AND PROJECTED: 1955–1964



all U. S. R&D was defense and space related, much higher than France (45%), the United Kingdom (33%) and numerous others in the 20 per cent range. By 1972, however, only 41 per cent of all U. S. R&D was spent by DOD, NASA and the AEC, i.e., the gap was considerably narrowed. The domination of DOD, NASA and AEC in federal R&D funding was also sharply reduced, from 92 per cent in 1960 to 76 per cent in 1972, a change which directly affects ARPA as a DOD agency.

ARPA's establishment thus coincided with what many regard as the "golden era" of support for R&D, particularly of federal support by those agencies whose missions were directly related to perceived national threats or the "external challenge." This "golden era" is easily pinpointed as the period between 1959 and 1964 when the "external challenge" R&D budget rose from a level of under $5 billion per year to over $13 billion. To illustrate how dramatic this change was, Figure I-3 compares the increase with what could have been projected on the basis of a straight-line extension of trends in the 1955-1959 period. As the Figure shows, if the trend in the Eisenhower years had continued, the "external challenge" R&D budget in 1964 would have been roughly $6 billion. In other words, the R&D response to perceived external threats doubled what would have been a highly reasonable projection in the late 1950's.

The great increases in military, nuclear and space research and development were, of course, directly related to the launching of Sputnik in late 1957 and the associated identification of apparent "gaps" in strategic missiles and diverse other areas of technology directly or indirectly related to national security (e.g., university output of scientists and engineers, foreign language training, etc.). By FY 1959 the response to these events was beginning to show up in R&D budgets and the "boom" continued for some five years.

Sputnik also led to the creation of ARPA in early 1958 as the temporary holding agent for civilian and military space programs. ARPA funding for these programs in 1958 and 1959, however, represented in part <u>transfers</u> of existing funds rather than a massive new effort, i.e., it <u>preceded</u> the build-up in R&D funding levels which came after Eisenhower Administration policy was reoriented and Congressional support for a substantial increase in R&D was reflected in legislation. The influence of the R&D boom on ARPA is better seen in the development of its non-space programs in the post-1959 period. Referring to Figure I-3, it can be seen that ARPA budgets increased at a rate as great or greater than that experienced by "defense-space" R&D in the late 1950's, but not nearly so dramatically as such R&D grew in the early 1960's. Because so much of the general boom was oriented to overcoming what was perceived to be imminent or existing gaps in defense systems and space, the lower growth rate in ARPA's "high risk" next-generation-oriented R&D is hardly surprising. The greatest increases also took place in "development" as opposed to "research" funding, and much ARPA work was in the research category. ARPA's growth in the early 1960's thus appears controlled by larger trends; it certainly did not set the pace.

The development of R&D trends in the latter half of the 1960's is also revealing as to the atmosphere in which ARPA research was conducted. Figure I-4 shows that a straight-line projection of "external challenge" research trends in the early 1960's would have led to a DOD-NASA-AEC outlay of almost $21 billion by FY 1969. In fact, however, there was very little growth over 1964 levels, with this component of R&D stabilizing around the $13-14 billion level. Factors influencing this stagnation included the failure of NASA to establish a major post-Apollo mission, the lessening to some degree of "cold war" competition with the Soviet Union, and the extended budgetary crunch created by the Vietnam War.

Referring to the ARPA budgetary developments also contained in Figure I-4, it can be seen that ARPA again reflects the overall trend. Whereas a straight-line projection from the early 1960's would have led to an ARPA budget of around $500 million by 1969, there was in fact a decline from a peak of nearly $300 million in 1965 to under $250 million in 1969. The fact that ARPA budgets declined while general "external challenge" R&D rose slightly may again well be attributable to a reduced sense of immediacy associated with ARPA work.

Figure I-5 continues the series of portraits of defense-space related R&D budgets through 1975. As can be seen, this category of expenditure has continued to stagnate, with actual budgets falling slightly below even the modest growth trend which might have been projected from the late 1960's. ARPA's budget reflects this general stagnation, with a gradual drop of expenditure levels to the $200 million previously cited.

In summary, ARPA's performance has been closely related to that of the "external challenge" sector as a whole, with an increasing budget up to the mid-1960's and a steady decline thereafter. The Agency was born in the most dynamic period of growth in research and development relating to national security and international competition and its subsequent decline and stabilization, in budgetary terms, directly reflects the end of the general R&D boom.

ARPA Leadership

The successive Directors of ARPA have had a major effect on the course of the Agency's history -- perhaps unusually great for an established government agency. The reasons for this strong influence of individual personalities traces to several factors, e.g., the small size of the Agency, the flexibility inherent in determining priorities for high risk advanced research, the lack of concise definition of ARPA's role within the DOD, and the Agency's rather loose, non-bureaucratic management

FIGURE I–4

SELECTED R & D EXPENDITURES, ACTUAL AND PROJECTED: 1959–1969

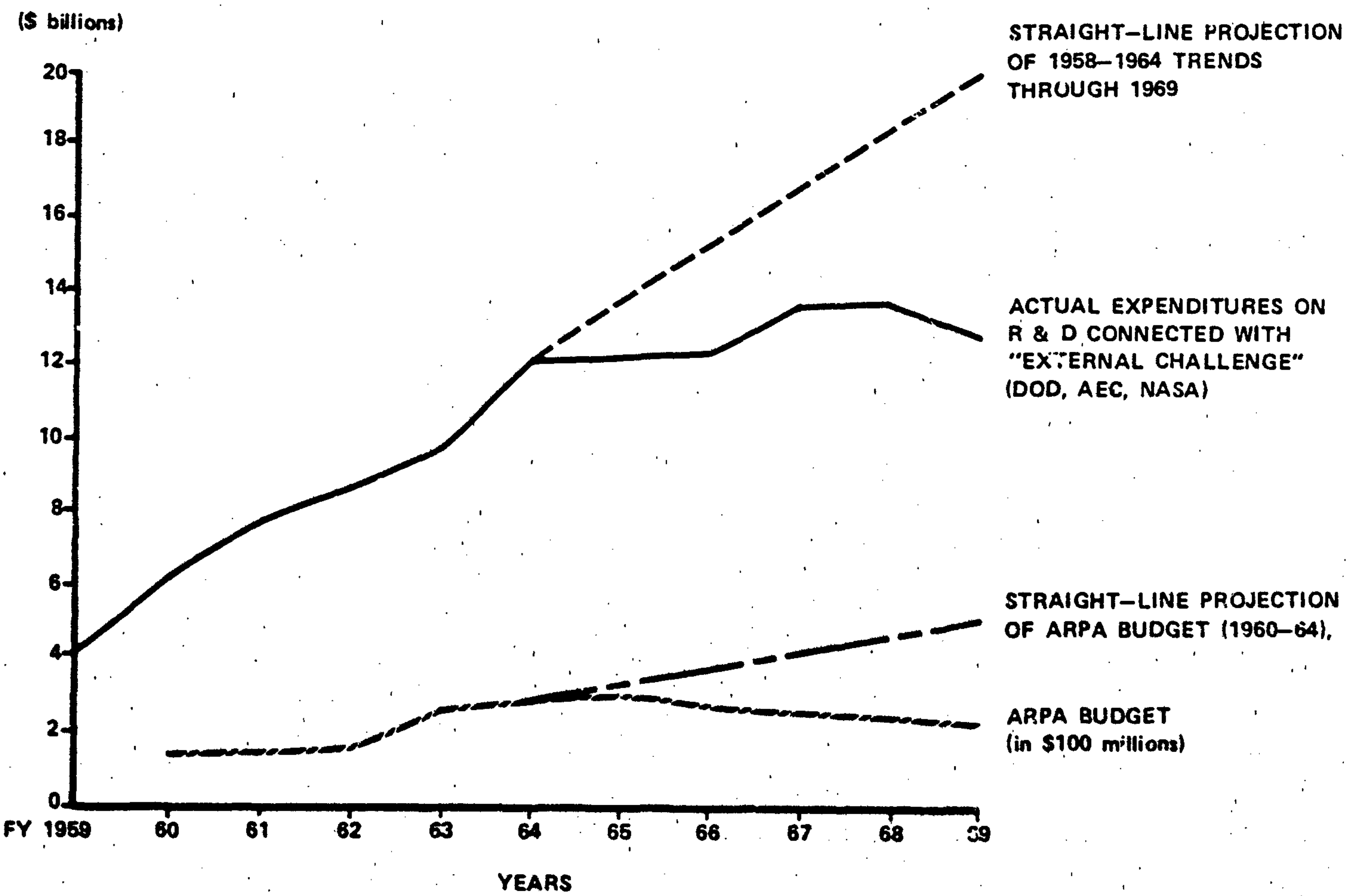
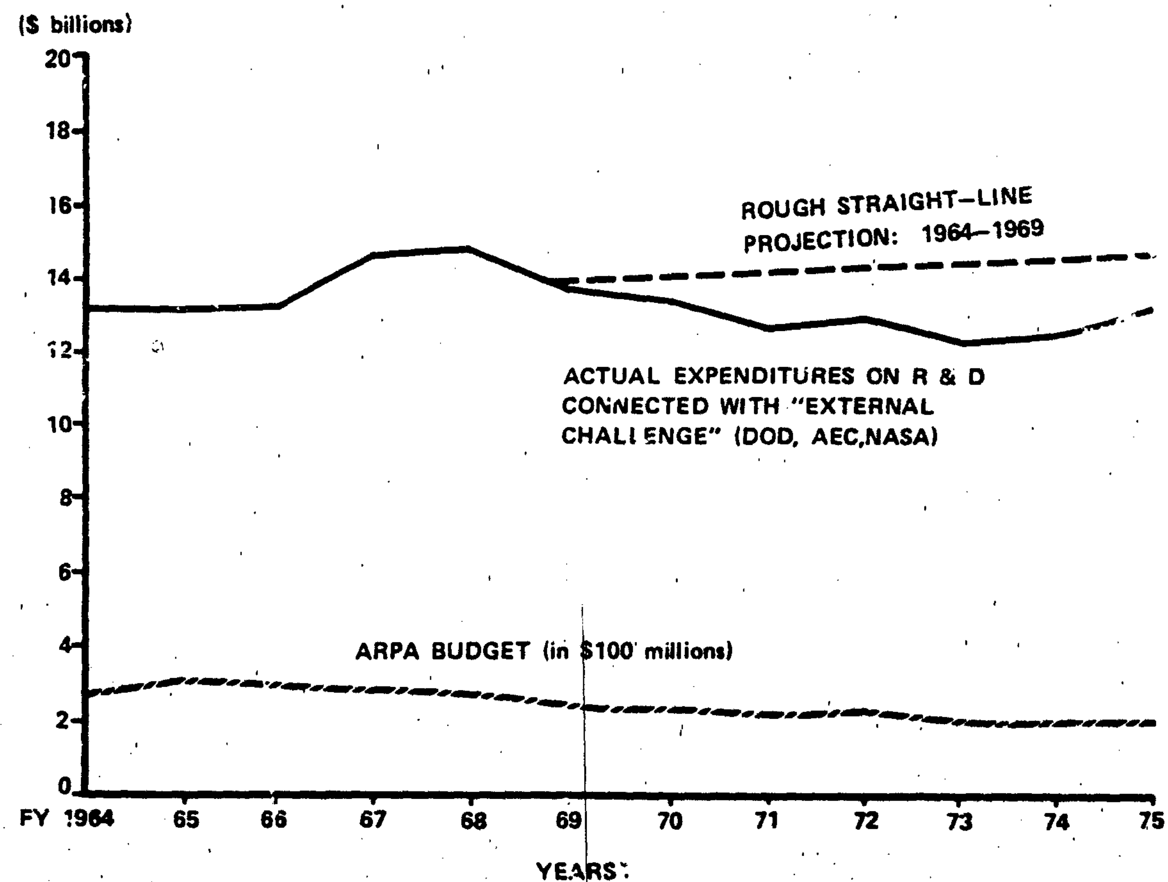


FIGURE I–5

SELECTED R & D EXPENDITURES, ACTUAL AND PROJECTED; 1964–1974



structure. Each of the ARPA Directors has, in any case, placed his personal stamp upon the agency and the historical account which follows is largely organized around the successive tenures of ARPA Directors.

Figure I-6 summarizes a number of salient facts about the ARPA Directors, including dates of tenure. Note that aside from Dr. S. J. Lukasik, who was Director during the early 1970's, the terms of ARPA Directors have been relatively short. Lukasik, listed as having served four years as ARPA Director, actually performed a number of Director's functions for another year while his predecessor (Dr. Rechtin) was serving in the additional capacity of Principal Deputy to the Director of Defense Research and Engineering. If the last year of Rechtin's term is deducted from his tenure, none of the ARPA Directors through 1970 have served actively in that role for more than two and a half years. Each of the ARPA Directors, therefore, may have been able to initiate new research directions, but until 1970 they enjoyed very little opportunity to preside over the fruits of those initiatives (especially given the inevitable lag between developing a concept and funding specific research projects).

Another interesting feature of the ARPA Directors is that except for the first Director, who was a business executive with no technical background, all ARPA Directors have been physicists or engineers and have had extensive prior experience in research and development activities. From 1961 through 1974, moreover, all of the ARPA Directors have had at least some professional connection with universities. The ARPA leadership has thus had a strong technical/scientific orientation over most of its history.

In terms of their routes to the ARPA Directorship, three Directors were elevated from within ARPA (Herzfeld, Lukasik and Acting Director Franken),* three came from the Office of the Director of Defense Research and Engineering (Betts, Ruina and Heilmeier, the current Director), and three came from outside the Defense Department (Johnson, Sproull and Rechtin). Only two of the Directors (Betts and Herzfeld) had no prior professional experience outside the government; Betts is the only one to continue a government career following his tenure as ARPA Director. As a rule, therefore, ARPA has not been headed by a career government professional, a factor which has enhanced the non-bureaucratic character of the agency over the years.

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* Major-General D. Ostrander served for a few weeks in an Acting Director capacity and is not included in this accounting. Dr. Franken's service in a similar capacity amounted to about eight months.

Figure I-6

THE ARPA DIRECTORS, 1958-1975

Name	Profession	Previous Experience: Government	Previous Experience: Non-Government	ARPA Head	Later Experience
Roy W. Johnson	Business Executive	War Production Board (World War II).	Vice President, General Electric Corporation.	2/58-11/59 (21 months)	Retired.
Gen. A. W. Betts	Engineer/ Military	Military RDT&E positions, 1935-1959, including ODDR&E, 1959.	None	12/59-1/61 (13 months)	Director, Military Application Division, AEC; Chief of Army R&D; Vice-President Southwest Research Institute.
Dr. Jack P. Ruina	Electrical Engineer	Deputy Ass't. Sec. of the Air Force, 1959-1960; ADDR&E/Air Defense, 1960-1961.	Professor at Brown (1950-54) and the University of Illinois (1954-59).	2/61-9/63 (31 months)	President of IDA; Professor at MIT; Vice-President for Special Laboratories, MIT.
Dr. Robert L. Sproull	Physicist	Consultant and contractual relationships with government research.	RCA, 1943-1946; Professor at Cornell, 1946-1963.	9/63-6/65 (21 months)	Vice President and Provost, Cornell; President, University of Rochester.
Dr. Charles M. Herzfeld	Physicist	National Bureau of Standards, 1953-1961; ARPA, 1961-1965 (Dir. BMD and Dep. Dir. of ARPA).	Lecturer and Professor (part-time), University of Maryland (1953-61).	6/65-3/67 (21 months)	Technical Director, I.T.T. Space Group.
Dr. Peter Franken (Acting)	Physicist	ARPA (Dep. Dir.), 1966.	Professor at Columbia, Stanford and University of Michigan (1948-66).	3/67-11/67 (8 months)	Professor at University of Michigan and University of Arizona
Dr. Eberhardt Rechtin	Electrical Engineer	JPL/NASA.	Cal. Tech., JPL (1949-67).	11/67-1/71 (38 months)	Principal Dep. DDR&E; ASD for Telecommunications; Chief Engineer, Hewlett-Packard Corporation.
Dr. Stephen J. Lukasik	Physicist	ARPA, 1966-1970 (Dir. NTD and Dep. Dir. of ARPA).	Bolt, Beranek and Newman and MIT (1952-55); Westinghouse (1955-57); Stevens Institute (1957-66).	1/71-1/75 (48 months)	Vice President, Xerox Corporation.
Dr. George H. Heilmeier	Electrical Engineer	Special Assistant to Sec. Def., 1970-1971; ADDR&E/ Electronics, 1971-1975.	RCA, 1958-68; David Sarnoff Research Ctr., 1968-70.	1/75	Not Applicable.

A Chronological Overview

As one of our respondents expressed it, with reference to ARPA's extraordinarily broad and varied involvement in defense R&D, ARPA is "a many splendored thing." To set the stage for the detailed historical account to follow, and to serve as a guide to the organization of the remainder of this report, the following summary outline of ARPA's history by chronological period is presented:

October 1957-January 1958: The Gestation Period. Sputnik was the trigger for establishing ARPA. The new agency was merely a part of the rather elaborate new national security-oriented restructuring of the manner in which government was to deal with science and technology which the Sputnik event forced upon the Eisenhower Administration. While there had been constant pressure building in the 1950's to refurbish the Defense Department's organization for R&D, reflected in warnings from the science community that the nation was in danger of "falling behind" in key areas of advanced technology, the Russian satellite provided the final impetus.

Secretary McElroy, sworn in just five days after Sputnik, took a highly personal hand in establishing ARPA and ultimately selected Mr. Roy W. Johnson as its first Director. The Secretary viewed ARPA primarily as a device for preventing uncontrolled inter-Service competition in space and ballistic missile defense R&D, which in turn was a thinly veiled surrogate for their highly emotional struggle for the unassigned military roles and missions of the future. These were expected to flow from continued dramatic advances in missile, space, nuclear, and other technologies. The perceptions and attitudes of the key prinicipals involved in ARPA's creation and start in life -- McElroy, Quarles, Killian, Johnson, and York, among others -- had a significant effect on what it was to become. Also important, however, were the views of the three Services and the Joint Chiefs of Staff. The specter of a new control mechanism for advanced R&D in the Office of the Secretary of Defense caused great consternation among them and generated bitter debate over the new Agency's charter. The compromise growing out of this debate produced many of ARPA's lasting characteristics namely, commitments to remain small, to rely on Service contracting resources, and to avoid creation of separate laboratories.

1958-1959: Roy W. Johnson, Director. ARPA was given jurisdiction over all U. S. space programs and over all advanced ballistic missile defense research (including, briefly, NIKE-ZEUS). It started life with a $520 million appropriation and formulated a two billion dollar budget plan. Its space projects had explicit Presidential approval. Within a year, however, many of the important space programs were unexpectedly selected for transfer to the new NASA and the ground was laid for returning most of the remainder to the Services, which had remained hostile to the Agency and often urged its abolition. Despite vigorous attempts to justify a major U. S. military space mission and to maintain ARPA as the DOD's "Space Agency," most of the space programs were gone by 1960. ARPA's initial role as a device for controlling inter-service rivalry in space and other high technology areas was further reduced with the creation of DDR&E, although ARPA continued to represent DOD on intergovernmental groups dealing with outer space policy.

ARPA in this period was staffed primarily by IDA personnel, quickly recruited from industry for that purpose; the IDA group was the dominant programmatic influence within ARPA. ARPA and its IDA staff made a large number of contributions to the emerging national space program during this brief period, affecting for example, the organization and content of the space booster programs, reconnaissance and weather satellites, the national satellite tracking system, and even early man-in-space efforts. Its contributions were, however, to be largely ignored in the annals of U. S. space history.

Tensions with the White House grew as Roy Johnson failed to satisfy the expectations of the President's Science Advisor or the President's Science Advisory Committee (PSAC) and President Eisenhower came to resent his outspoken championing of military space activity. McElroy's departure, the death of Deputy Secretary Quarles, and Dr. Herbert York's elevation from Chief Scientist of ARPA to become the first Director of Defense Research and Engineering (DDR&E) had the effect, symbolically and otherwise, of isolating and downgrading ARPA relative to the image projected at its creation. Roy Johnson left the Agency a disillusioned man in late 1959. Yet despite the space struggles and ARPA's ultimate defeat in that area, the Agency survived and prospered. Although Johnson personally had paid relatively little attention to them, the Agency received assignments in solid propellant chemistry, the materials sciences and nuclear test detection during his tenure, each with links of some sort to the President, PSAC, or the Federal Council on Science and Technology. These together with the ballistic missile defense effort, were to form the core of the ARPA program for the next decade.

<u>1960: Austin W. Betts, Director</u>. Ballistic missile defense R&D emerged as ARPA's largest program following the space era, followed by the substantial assignments of the late Johnson period in nuclear test detection and materials sciences. In the face of the severe reductions in budget and status which attended the space program transfer process, and the creation of both NASA and DDR&E, ARPA adapted to the new situation. It undertook numerous smaller assignments, mostly short-lived, from the DDR&E and concentrated on establishing that it could be a useful and responsive mechanism within the Office of the Secretary of Defense. The adjustments made in this period enabled a vigorous ARPA to be rebuilt in subsequent years.

Brigadier General A. W. Betts, appointed to ARPA from a DDR&E post, accepted and facilitated these adjustments. In his one year as Director, Betts sought to heal the wounds of the past and to modify the style and organization of the Agency, particularly through undertaking DDR&E-approved projects which had multi-service implications or which did not fall within any given Services' mission. As part of the Betts reorganization and general "normalization" of Agency activities, the IDA staff was displaced by the development of a more conventional staffing pattern using military officers and Civil Service personnel. Under Betts, the urgency of many ARPA assignments began to decline and much of the work takes on the flavor of long-term basic research. Support of such research became both a strength and a vulnerability of the Agency for many years to come.

<u>1961-1966: Jack P. Ruina, Robert L. Sproull and Charles M. Herzfeld, Directors</u>. From 1961 through 1966 ARPA built on the many program "charters" generated earlier. It was an era of expanding R&D activity for the Agency. The budget grew considerably beyond its post-space transfer low of $186 million, but did not match its original half billion dollar apogee; it peaked at just under $300 million. The increased funding closely tracked national trends in the growth of military and NASA R&D. This was, as previously noted, the "golden age" of R&D and technology. ARPA shared in the largesse.

While the overall 1961-1966 period was one of relative ARPA affluence, acceptance and stability, the tenures of each of the three above-mentioned Directors did have its own distinctive characteristics.

Dr. Ruina's directorship (1961-1963) was a time of investment. Like Betts, a York appointee from the DDR&E staff, Ruina placed great emphasis on quality of personnel and programs, believed in the value of a strong, high quality, basic research effort and turned his personal interests to ARPA's major "Presidential issue" assignments -- ballistic missile defense (DEFENDER) and nuclear test detection (VELA), both related to subjects of vigorous national debate. Ruina ranked scientific quality above military relevance and did much to strengthen ARPA's image as a highly capable technical organization willing to place substantial support behind potentially important R&D programs frequently of a high-risk character.

Dr. Sproull's tenure (1963-1965) was a period of spectacular successes and great continuity, a period marking the peak of ARPA'- acceptance and impact. Throughout the ARPA program, R&D investments m during Dr. Ruina's period and in earlier years began to pay off and ARPA accomplishments began to be widely recognized. Sproull, who had come to ARPA from a university environment but was rather sensitive and attentive to issues of Defense relevance, sought to reconcile ARPA's divergent efforts in basic research and in highly applied military problems. Sproull's ARPA witnessed many achievements in both areas and drew relatively little criticism from within DOD or from the Congress.

Dr. Herzfeld's period (1965-1967) is perhaps best described as a period of Agency maturity. Herzfeld's ARPA had many solidly "established" programs. They produced a continuing flow of accomplishments, but without quite the same impact overall as earlier achievements in what were considered to be fresh new problem areas. Herzfeld, promoted to the directorship from within ARPA, was a proponent of a strong continuing ARPA role in its chosen fields, especially those relating to Presidential issues. Before his departure, however, pressures for change in a Defense Department beset with growing Vietnam problems led ARPA to the brink of severe crisis.

Looking at ARPA's programs throughout 1961-1966, DEFENDER work normally accounted for about 40-50 per cent of the total budget and was generally well-received in DOD, the White House, and the Congress. DEFENDER was credited with major contributions to ballistic missile defense and strategic offensive system developments, notably in the areas of radar, reentry measurements and penetration aids development. Several major ARPA-sponsored studies examining the interplay of strategic offensive capabilities and opposing defensive systems had major impact. A DEFENDER "technical community" was developed and nurtured, and it became extremely influential on missile defense matters quite independent of specific ARPA programs. DEFENDER has been attributed with a major role in influencing the course of ballistic missile defense decisions from NIKE-ZEUS, through NIKE-X, to SENTINAL/SAFEGUARD, and with a significant impact on the evolution of the strategic deterrent in general.

The nuclear test detection research program was closely intertwined with the negotiations that: (a) produced the Limited Test Ban Treaty, and (b) failed to produce a comprehensive test ban agreement. The Agency's visibility in high policy councils was relatively high in this field.

Counterinsurgency research (Project AGILE) grew from a small program (initiated from within the ARPA staff, but acquiring White House sanction) to a major effort, including establishment of large field units in Vietnam and Thailand and the placement of small offices in Lebanon and Panama. Difficult staffing, management, planning, and programming problems emerged in AGILE, but were relatively controlled throughout the early 1960's.

Considerable emphasis was placed on ARPA's support of basic research throughout the period. A major role in the computer sciences was developed and expanded. A small behavioral sciences effort was initiated. The Interdisciplinary Materials Science Laboratories and other materials science work reached an annual funding level approaching $30 million. Basic research in seismology, atmospheric physics and many other fields was strongly supported witnin VELA and DEFENDER.

Compared to 1958-1960, the Agency seemed to have established a "steady state" condition, Service bureaucratic sniping was reduced, and work on the "Presidential issues" -- missile defense, nuclear test detection, penetation aids, and counterinsurgency -- stretched the Agency, alongside major basic research efforts enjoying the support of large parts of the scientific community.

1967-1970: Eberhardt Rechtin, Director. The enormous demands of the Vietnam War and general budgetary pressures, combined with a growing general disillusionment with the ability of science and technology to solve major problems (both military and non-military), resulted in a halt in ARPA's budgetary and programmatic growth. Major missile defense policy decisions in 1967, resulting in a commitment to deploy a light BMD system, led to the transfer of the core of the DEFENDER program to the Army in 1968, primarily to upgrade the Army's advanced R&D capabilities. This was the first major program transfer since the military space transfers of 1959. AGILE and ARPA's behavioral sciences program came under increasing attack in DOD and especially in Congress as Vietnam frustrations grew. The breadth and scope almost all of military-sponsored research was seriously questioned. The Materials Science program, particularly its sponsorship of university laboratories, was severely criticized as definitions of militarily relevant research were narrowed, leading to eventual transfer of the laboratories to NSF. Nuclear test detection research declined in prominance with lessening interest in a comprehensive test ban. The Mansfield Amendment was passed, reflecting Congressional skepticism about the purposes and management of Defense research, some of it explicitly ARPA-sponsored; the Amendment calling, again, for much stricter criteria of relevance. The incumbent DDR&E, Dr. J. Foster, under attack from all sides, determined that ARPA had to be reformed to adjust to these new realities and appointed Dr. Eberhardt Rechtin to accomplish this task.

Under Rechtin ARPA endeavored to change, in part by moving toward closer linkages with specific Service and DDR&E requirements, and survived the period with an uncertain mix of old programs and new initiatives and a somewhat reduced budget. Throughout Dr. Rechtin felt handicapped by an "idea poor" R&D environment.

1971-1974: Stephen J. Lukasik, Director. Adjustments forced by events in the preceding period culminated in considerable internal reorganization of ARPA, bureaucratically and substantively. Counterinsurgency research was abandoned. Several segments of DEFENDER work left behind by the transfer were in the process of forming the basis for a new Strategic Technology program. ARPA contemplated phasing-out nuclear test detection research; indeed, complete transfer of the program to the Arms Control and Disarmament Agency (ACDA) was debated on the floor of the Senate in response to an incident arising out of a technical meeting at Woods Hole. The outcome was neither phase-out nor transfer, but relatively low level continuation amidst recognition that the program's political salience was decidedly reduced. In essence, the door was closed on the original "Presidential issues" that had been the foundation of ARPA's work for a decade. No comparable mandates on broad new issues were assigned to the Agency.

On the other hand, a number of new assignments were generated in specific Defense problem areas, frequently in the context of joint Service-ARPA projects. The style of ARPA R&D management appeared to change from one of great flexibility within fairly general mission categories, to a much more focussed management approach combined with a more clearly defined user orientation.

Internally, three offices were combined in mid-1972 to form the current Tactical Technology Office. Behavioral science research was reoriented to less controversial areas and the cognizant ARPA office purposely renamed. The Strategic Technology and Information Processing programs, together with the emerging tactical research effort, became the core ARPA programs. As noted, the Agency further sought to accommodate and adjust to the conflicts of the late sixties by emphasizing applied exploratory development tasks rather than basic research (a change especially noticeable in the information processing, human resources and materials areas); by becoming increasingly involved in joint undertakings with the Services (including joint funding, committee coordination and highly specific divisions of tasks); and by stressing specialized high technology undertakings that were important, but of a less controversial or high visibility nature than many earlier programs. "Relevance," "problem-orientation," and "transfer" to the Services became the modern ARPA's watchwords. The period appeared to be more "idea rich" than its immediate predecessor, perhaps due to the deferral of many high technology problems during the Vietnam War era, but no dominant "central program themes" emerged on the model of earlier "Presidential issue" assignments. ARPA's workload was characterized by rather discrete "program elements" and projects.

The ARPA budget stabilized at around $200 million per year. The Secretary's Blue Ribbon Panel recommendations to abolish DDR&E and to expand ARPA into the central repository for all 6.1 and 6.2 R&D in DOD were debated and rejected. ARPA was designated a Defense Agency, returning it, at least in a formal sense, to a more direct relationship with the Secretary of Defense.

SPUTNIK: THE TRIGGER

The Summer of '57

In retrospect, the environment of the late 1950's within which ARPA was created was perhaps more unique than the Agency itself. Issues were readily separated into black and white categories with little scope for "gray areas" and convictions were expressed in extreme forms. On the one hand, for instance, communism was seen as a physical and immediate threat to national security. On the other hand, it was generally believed that science and technology could do anything and that the U. S. had a monopoly on these keys to progress. When the Soviet Union demonstrated apparently equivalent or perhaps better skill in technical areas, the American perception of the threat and the belief in science were married to produce genuine fear.

By the summer of 1957, just prior to the Sputnik event, the great hopes for peace after World War II had long since vanished. The United States and the Soviet Union were obsessed with the Cold War, which had been enormously heightened by both the 1956 Soviet suppression of the Hungarian uprising and the Anglo-French Suez invasion. It is very hard to over-exaggerate the depth of feeling and bitterness which then prevailed. As President Eisenhower put it, destruction of "democracy in general and ... the United States in particular" was the primary objective of the Soviet camp.[4] Nobody challenged that assessment. Indeed the only serious argument arose over how well prepared the United States was to defend itself.

Eisenhower, overwhelmingly reelected in the 1956 crisis atmosphere, still perceived the Soviet threat in long range terms. He believed they would not be able to challenge our nuclear superiority directly for some years. He worried that in the short run it would be Soviet strategy to weaken us economically by means of stimulating recurring crisis events to which we would overreact with high military budgets. Hence he postulated a New Look defense policy which called for slimmed down military forces, principally reliant on the retaliatory striking power of SAC.

On the other hand, there were a few voices, many of them scientists, with a decidedly different opinion about Soviet capability to develop and exploit modern weapons technology in the near term. They were later in a position to enjoy "I told you so" status and considerable influence was conferred upon them almost instantly when Sputnik was launched. Commencing in the early 1950's, various intragovernmental committees and advisory groups began to sound notes of warning, predicting that the Soviets did have the capacity to attack us with nuclear weapons, that they were ahead in ICBM development and that we were falling behind in preparing adequate air and missile defense systems. The National Security Council Planning Board (1952), the von Neumann Committee (1954), the Technological Capabilities Panel or Killian Committee (1955), and the Gaither Committee (1957) were among these groups and names such as James Killian, George Kistiakowsky, Jerome Wiesner, Herbert York, I. I. Rabi, Ernest O. Lawrence, and Donald Quarles were associated with them in one capacity or another. Usually their views were expressed in highly classified surroundings, but occasionally the debate would break out in public forums, the Symington Air Power hearings of 1956 being a notable example.

James R. Killian was a foremost exponent of the view that the United States was seriously underestimating the Soviets and failing to move decisively to reduce vulnerabilities. Testifying at length before the Symington Committee in June 1956, Killian articulated the problem in terms which were to become common currency in the months ahead. "The kind of armaments race in which we are now involved" he stated, is largely a race in military technology."[5] And to his mind, and that of an important segment of the scientific world whose opinions he reflected, the Soviets were committed to that race. Killian stressed that they were producing more machine tools than the U. S., training more scientists and engineers, and moving more quickly from basic ideas to pieces of military hardware. He advised the Congress to commission an in-depth study of what he called "Survival in the Age of Technological Contest," the outcome of which would be a comprehensive strategy for maintaining U. S. technological supremacy.[6] This notion of a technological race with the Soviets began to take on a quasi-mystical quality, partially captured in Killian's summation that "I cannot escape the feeling that events of the technological age are moving faster than our perception of their meaning .... and that we need more carefully to tune in our receivers to pick up the changes that lie ahead."[7]

The President was very reluctant to accept these warnings, although he did act on the von Neumann Committee recommendation that development of an ICBM, utilizing recent breakthroughs in nuclear warhead size, be accelerated. Unfortunately for the President, this work proceeded in great secrecy, thereby creating a large void in the public mind against which subsequent Soviet successes appeared somewhat larger than life; however, Eisenhower was deeply committed to the notion that the U. S. should go to great lengths to avoid unnecessary "saber-rattling," a behavior he felt was a dangerous stimulus to the arms race and to belligerent acts on the part of the communist side. One immediate effect of the green light on missile development, however, was creation of entirely new, streamlined special purpose R&D agencies within each of the Services: the Air Force Western Development Division, later Ballistic Missile Division (1954-55), the Navy's Special Projects Office (1955) and the Army Ballistic Missile Agency (1956). Each was designed to eliminate red tape and carry out top priority missile R&D projects under severe time pressures. Thus the impulse to set up ARPA in response to the satellite threat had organizational antecedents.

In mid-1957, a second factor served to reinforce and give great credibility to the growing fear of Soviet power and intentions. This was an equally intense conviction that science could do anything. The very weapons that inspired fear -- atomic, thermonuclear, missiles and satellites -- were representative of a period in which scientific and technical progress seemed to materialize in cascades. The potentialities of the atom and outer space were genuinely felt to be limitless. The feasibility of almost any technical idea was a foregone conclusion -- the only problem seemed to be "getting around to doing it." The whole process of transforming scientific progress into innovation was assumed to be automatic. Vannevar Bush had spoken of the endless scientific horizon in 1946 and events since had seemed to confirm his vision and perhaps moved beyond it in some respects.* Scientists, engineers and decision-makers alike:[8]

> ... had come to believe that the normal technological state of affairs was one of a continuing flow of ever new scientific discoveries automatically leading to even more exotic applications in turn inevitably producing great new political and strategic advantages for whoever got there first.... The breakthrough, or the 'quantum jump,' became not only the expected norm, but also the desideratum.

Mostly, of course, it was assumed that the U. S. would always be first. The chilling aspect of the gradually accumulating Soviet successes was that they all "appeared much faster than even the most pessimistic American scientists had anticipated," and that in itself served powerfully to confirm the science-can-do-anything conviction.[9]

Acceptance of the communist threat and belief in rapid scientific change began to feed on one another. In the spring of 1957, following a personal interview with Khrushchev, Joseph Alsop predicted that the Soviets would soon seek to frighten the West by demonstrating some fearful new weapons.[10] On August 27, 1957 (six weeks before Sputnik) the Russians announced the successful test of an ICBM. Even so, many discounted it as propaganda. The Sputnik launch on October 4, 1957 was to demonstrate clearly, however, that the Soviet Union did possess a rocket capable of sending warheads intercontinental distances, and the orbiting satellite served as evidence that Soviet technology could yield completely unanticipated surprises.

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* Bush had called the notion of a continent-to-continenet "3000 mile high-angle rocket shot," carrying a nuclear bomb, impossible. Similarly, the imaginative Theodore von Karman ignored earth satellites in his visions of the future. Their skepticism was felt to have helped impede those within the Services who sought to develop missiles and satellites in the 1940's and 1950's. (See R. Cargill Hall, "Early U. S. Satellite Proposals" in Eugene M. Emme (ed.) The History of Rocket Technology (Detroit: Wayne State, 1964) 68 and Constance M. Green and Milton Lomask, Vanguard: A History (Washington: Smithsonian, 1971) 8.)

By late summer, 1957, premonitions were growing that the USSR was capable of matching, perhaps exceeding, U. S. prowess in military science and technology. The dramatic launching of Sputnik in early fall confirmed them. Soviet detonation of nuclear and thermonuclear devices, successful launching of ICBM's and finally the Sputnik successes, all "ahead of schedule," literally induced an element of fear into the situation.* It is extremely difficult today to re-create the intensity with which this was felt and expressed. It is no exaggeration, however, to say that it simply dominated American political life and defense and foreign policy thinking. As President Eisenhower put it, "Americans realized that, as never before in history, they must thenceforth live under the specter of wholesale destruction."[11]

Sputnik: Fear and Consternation

The Sputnik events, especially the 184 lb. Sputnik I on October 4, 1957 and the 1120 lb. Sputnik II, containing the dog Laika, in November mesmerized the country and the world. Shock and fear were universal. Although there was considerable confusion in the public mind about the significance of space and satellites on the one hand and large rockets and missiles on the other, the net effect was genuine worry. Many feared some sort of orbiting space platform containing a nuclear weapon, or something worse. No one could be absolutely sure of what the Sputniks actually were capable of doing. Those inside government could see clearly that the Sputnik successes provided smashing confirmation of the Soviet's August claim to having an ICBM. Sputnik III, orbited in May 1958, weighed 7000 lbs. It demonstrated that they had both the booster and guidance capability to send ICBM's to the United States. Very soon the notion of the "missile gap" was launched and rapidly politicized, along with a series of "ornate horror stories about imminent threats to our very existence as a nation."[12] Above all there was a lingering fear that if the Soviets could achieve such magnificent scientific and technological feats in missilry and space flight, what else might they do? American superiority, so long taken for granted, was in tatters. Even the sufficiency of our deterrent forces was in question.

Accordingly American prestige around the world was threatened. Prestige was seen to be a function of military power which, as noted above, was increasingly seen to be a function of science and technology. Performance in outer space rapidly became the short hand index of a Great

* The Soviet Union tested its first nuclear device in September 1949, three years ahead of intelligence estimates, and its first thermonuclear device in August 1953. A Soviet ICBM flew successfully August 27, 1957. Sputnik I was launched October 4, 1957; Sputnik II on November 3, 1957 and Sputnik III on May 15, 1958.

Power's standing. It was presumed that nations would "choose up sides" with the U. S. or the USSR on the basis of their respective scorecards in space. Indeed the Under Secretary of State for Political Affairs testified that other nations construed space achievements as symbols of national capabilities and effectiveness across the board. Preoccupation with prestige and its measurement became a characteristic of the late 1950's and early 1960's. Demands for rapid evidence of progress were made everywhere and the U. S. began to endure:[13]

> ... a period of mental turmoil and vocal soul-searching ... that can scarcely be described as dignified. In retrospect it is easy to smile at some of the exaggerated alarms and groundless assumptions that filled newspaper columns and trumpeted from public platforms as the significance of the Soviet feat became apparent. The smug chuckle of hindsight however, cannot efface either the importance of the event or the intensity of the change it wrought in American thinking.... [Sputnik's] two transmitters would fail twenty-three days after launch -- but their arrogant beeping would continue to sound in the American memory for years to come.... Gone forever in this country was the myth of American superiority in all things technical and scientific.

"Insiders" and scientists felt much the same way. For better or for worse, Sputnik became a very definite watershed in American public life. A composite of the recollections of Dr. Herbert York, first ARPA Chief Scientist and the first Director of Defense Research and Engineering, serves as a valid summarization of virtually every observer's assessment of Sputnik's impact, to this day:[14]

> It became the crucial psychological landmark in the course of post-war arms development, affecting almost every facet of defense operations.... A wave of shock and consternation swept the United States and most of the rest of the world ... everyone was shocked and the reactions of the sophisticated and the unsophisticated differed only in degree ... general consternation ... pervaded all levels of American society and government.

The press, the public and the Congress, regardless of party, were almost frantic. Senators such as Henry Jackson, Stuart Symington and Lyndon Johnson directed a steady stream of criticism at the Administration for indecisiveness, confusion and lack of urgency. The aerospace trade press was vitriolic. The President's relatively bland public posture generated even greater attack on his policies. Writing his memoirs years later he said that the intensity of public concern was the most surprising aspect of Sputnik to him and he conceded in retrospect that "there was ample stimulus for public uncertainty."[15] He argued at the time, however, that the Sputnik launch had not changed our national security "one iota" and professed not to understand all the uproar. His Special Assistant, Sherman Adams, moreover ridiculed the notion of keeping score in a celestial basketball game.[16] And Deputy Secretary of Defense Quarles testified in November 1957 that:[17]

> I find in the existence of the first satellites no cause for national alarm. In this respect I am disagreeing with many people who have been saying 'Let's beat them'; 'Let's put up a bigger satellite'; Let's hit the moon with a rocket.... We must not be talked into 'hitting the moon with a rocket' just to be first, unless by so doing we stand to gain something of real scientific or military significance.'"

It was a "no sell" proposition. As tempers and a public clamour that "something be done" mounted, the White House laid plans to react.

Science was unavoidably joined with Soviet imperialism in the minds of men who had not too long before wondered what would have happened if Hitler had gained access first to atomic weapons. 1957 was indeed a fateful year: Sputnik flew and the Soviet Union threatened nuclear attacks on Norway, Denmark and Turkey. A report prepared under the direction of Henry Kissinger, and published January 6, 1958, summed it all up:[18]

> Mankind ... is faced by two somber threats: the Communist thrust to achieve world domination that seeks to exploit all dissatisfactions and to magnify all tensions; and the new weapons technology capable of obliterating civilization....
>
> Looking at the world from the perspective of our past isolation and recent nuclear supremacy, perhaps the most difficult thing for us is to accept the reality of our peril. Other more exposed nations have had to learn to live over a period of centuries with the awareness that their existence might be imperiled by foreign attack. It is a new experience for Americans.
>
> A new technology of unprecedented power and destructiveness has placed <u>all</u> nations of the world in dire peril....

> What gives this weapons technology its ominous quality is that it is in the hands of a Communist movement which has proclaimed for over a generation now -- the last time in the Moscow declaration of all Communist states on November 16, 1957 -- the irreconcilability of its system with that of the free world.... Should we ever allow the U.S.S.R. and Communist China to attain strategic superiority, we can be certain that subsequent events will be brutal. And the power of these states, particularly the U.S.S.R., has been growing both absolutely and relative to the United States until today it constitutes a grave threat.

Fortunately, the fervent belief in unending scientific progress offered a way out. The U. S. could readily mobilize itself to catch up with and beat the Soviets, given the will. The issue was not "whether," but simply "how fast?" As the President himself said in a radio-TV address a month after Sputnik: "The world will witness future discoveries even more startling than that of nuclear fission. The question is: Will we be the ones to make them?"[9] The United States proceeded at first gradually, then with growing speed, to insure that it came out on top, mounting in the end a prodigious effort to secure technological supremacy. ARPA was among the earliest results of this process.

The Eisenhower Response

Although ARPA has often been referred to as the organizational response to Sputnik, it was actually one among several. The first and most important were creation of the post of Special Assistant to the President for Science & Technology* and the President's Science Advisory Committee (PSAC). In parallel with the President's moves to instituionalize science in the White House, the Secretary of Defense commenced some organizational shuffling of his own, ultimately resulting in ARPA. The record indicates that these Defense Department initiatives were dependent upon very strong Presidential support.

Despite the bland public facade initially shown by the Administration after Sputnik, conditions inside the White House were in a state of turmoil:[20]

> That week after the first Sputnik was one prolonged nightmare. Any number of people ... were dashing in and out of the President's

* For ease of reference hereafter referred to as the President's Science Adviser.

> office. Each new visitor had a longer face than the one before.

Many of those faces were also red, since both the Sputnik event and its likely impact on world opinion had been foreseen. Indeed a Project RAND report entitled "Preliminary Design of an Experimental World-Circling Spaceship," which found the satellite concept feasible, concluded in May 1946 that:[21]

> The achievement of a satellite craft by the United States would inflame the imagination of mankind, and would probably produce repercussions in the world comparable to the explosion of the atomic bomb.... Since mastery of the elements is a reliable index of material progress, the nation which first makes significant achievements in space travel will be acknowledged as the world leader in both military and scientific techniques. To visualize the impact on the world, one can imagine the consternation and admiration that would be felt here if the U. S. were to discover suddenly that some other nation had already put up a successful satellite.*

While that early report probably had few readers, prominent officials had echoed its findings in the two years before Sputnik. Donald Quarles, who made the decision to select Vanguard as the U. S. satellite project for the International Geophysical Year, told the President in May 1955 that the first country to orbit a satellite would accrue "considerable prestige and psychological benefits" for itself because demonstration of such an advanced technology and "its unmistakeable relationship to intercontinental ballistic missile technology might have important repercussions on the political determination of free world countries to resist Communist threats."[32] The President's Special Assistant, Nelson Rockefeller, was even more explicit in forwarding the Quarles paper to the NSC: [23]

* This was Project RAND's first Air Force assignment. Symbolically, it arose because the Air Force had heard that the Navy was doing a satellite study. Project RAND (then at Douglas Aircraft) was instructed to put together something for the Air Force to say on the subject, on a very tight time schedule. (Discussion with J. R. Goldstein, retired RAND Vice President, July 9, 1975.)

> I am impressed by the costly consequences of allowing the Russian initiative to outrun ours through an achievement that will symbolize scientific and technological advancement to people everywhere. The stake of prestige that is involved makes this a race that we cannot afford to lose.

As early as November 1956 the President received intelligence estimating that the Soviet Union would be capable of launching a satellite after November 1957.[24]

The Vanguard decision had been highly controversial. Sputnik immediately re-fueled that argument and the Army insisted that had the Redstone rocket been selected instead of Vanguard, the United States would have been in space ahead of the Russians. On October 8, the day after Sputnik was launched, the President called in at various times the Vanguard program director, Dr. Hagen; DOD's Special Assistant for Guided Missiles, William Holaday; Deputy Secretary Quarles; and the President of the National Academy, D. W. Bronk. Before the day was over he had ordered Secretary Wilson to prepare the Redstone for use.[25] It was this rocket that lifted the 23 lb. Explorer I into orbit on January 31, 1958, about a week before the formal establishment of ARPA.*

The President also sought advice from scientists outside government. Many of them shared his skepticism about the limited significance of Sputnik I itself, but insisted passionately that the Soviets intended to, and could, achieve scientific and technological superiority in the next 10-20 years. They stressed an alleged "gap" in science education and the elevation of scientists to elite positions in Soviet society; they urged that new arrangements were needed in the U. S. to bring science into government. The President was forced to deal increasingly with scientific and technical subject matter without visible staff help. At best, science got called in after the fact and there certainly was no continuity to the process. Establishment of a Presidential science adviser, supported by an advisory group of eminent scientists, was proposed. According to an attendee at one of the key sessions, "The President said that he had felt a need for such assistance time and again."[26]

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* The Army, of course, publicized this success with great glee. Shortly after the triumph a large book of congratulatory telegrams, received after the Explorer I launch, was published in a fashion which was an obvious slap in the face to the highly troubled Vanguard program.

In particular, the President held a number of serious discussions with members of the Science Advisory Committee of the Office of Defense Mobilization (ODM):[27]

> With great enthusiasm and determination the President wanted the scientists to tell him where scientific research belonged in the structure of the Federal government, how the output of our colleges and universities was to be increased and how we were going to meet the competition during the next ten years.

They did. Within a month the Science Adviser and the President's Science Advisory Committee (PSAC) emerged as the first organizational responses to Sputnik. They were the initial building-blocks in a rather elaborate mechanism for institutionalizing science in government that survived into the Nixon presidency.

In a major policy address to the nation on "Science in National Security" (November 7, 1957) the President spoke somberly about the future:

> I must say to you, in gravity, that, in spite of both the present over-all strength and the forward momentum of our defense, it is entirely possible that in the years ahead we could fall behind. I repeat: We could fall behind -- unless we now face up to certain pressing requirements and set out to meet them at once.

He announced the post of Special Assistant for Science and Technology, and named Killian to it, to "follow through on the scientific improvement of our defense," and to insure that "the entire program is carried forward in closely integrated fashion, and that such things as alleged interservice competition ... shall not be allowed to create even the suspicion of harm to our scientific and development program." Military and space research and technology thus were the primary motivating forces for creation of the Science Adviser and PSAC. They were to exercise great influence in these fields, a matter of some importance to the as yet unborn ARPA.

In the same address, the President up-graded Holaday to Director for Guided Missiles in DOD, a cosmetic move (also aimed at overcoming "interservice blocks") which had no lasting effect, and stated that he and the Secretary had agreed that "any new missile or related program hereafter originated will, whenever practicable be put under a single manager and administered without regard to the separate service." The latter definitely foreshadowed an ARPA. Two weeks later McElroy announced his intention to set up a single manager for space and missile defense programs. Centralization and control were in the air.*

The Scientists

As noted above, the views of the science advisers on the organization of military science and technology definitely influenced Eisenhower's personal judgments. Along with their philosophy of the substance and conduct of military R&D, these views warrant careful examination because directly and indirectly they shaped ARPA's future for a decade. Given this lasting influence, a more detailed account of the perspectives of the Eisenhower science advisers is in order before proceeding to the organizational changes in the Defense Department leading to ARPA.

The pivotal figure is Killian, a non-scientist who had the ability to absorb, shape and reflect in a highly articulate way the views of a large segment of American scientists. He appeared to be a near unanimous choice as the spokesman of science and his selection by Eisenhower as the first Special Assistant for Science and Technology was greeted with great favor. Seldom has a man so successfully served as the spokesman of a class and we use him here in that role.

In a remarkable piece of testimony at the Symington Air Power Hearings in June 1956, almost a year and a half before Sputnik, Killian developed a number of issues and positions which were to become the bellweathers of American R&D policy in the post-Sputnik era. These ideas were shaped throughout the early 1950's, largely by a group of scientists who had come to fear that government either misused or misunderstood modern science and technology. They had been working in consultative and "summer study" capacities for the AEC, DOD, and occasionally the White House. When the bell rang -- Sputnik -- they were ready with a rather complete agenda and proceeded to act on it. Much of their earlier

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* In addition to the organizational changes, Sputnik induced an incredible array of decisions in late 1957 and early 1958. For instance, spending on Atlas, Titan and Polaris was accelerated. Instead of choosing between the Thor and Jupiter IRBM's, both were approved for production. SAC was dispersed and put on alert to reduce its vulnerability. Rapid installation of the DEW line and full scale development of the NIKE-ZEUS BMD system were authorized. In response to a personal visit from Prime Minister Macmillan, the President obtained Congressional sanction to relax previous prohibitions on the sharing of nuclear data and materials. Development and testing of tactical nuclear weapons, and plans for integrating them into NATO forces, were speeded up. Urgency was the keynote. Clearly ARPA was ushered into a frantically active and aggressive Pentagon environment.

preaching in the wilderness was redeemed by the Soviet scientific spectaculars -- it now took on the aura of revealed truth.

On the organizational side, Killian firmly believed that the traditional Service roles and missions had been outmoded by science and technology. Global weapons systems, such as air defense or ICBM systems, required new organizational patterns if they were to be developed without waste of men and resources and properly managed in terms of "their wholeness as systems:"[28]

> So far we have not been able, in the definition of the roles and missions of the Services, to keep pace with evolving weapons-systems technology and as a consequence we lengthen our lead time, we needlessly increase costs, and we find it difficult to avoid friction and duplication of effort.
>
> ... a revolution is upon us as a result of technological advance and ... the inevitable logic of present-day weapons technology, as well as non-military technology, is to force new patterns of organization affecting traditional departmental boundaries and even political concepts.

The military also lacked enough men with "the capacity to visualize and direct the integration of complicated technological systems."

These were themes struck two years earlier (June 1954) by Killian during the Riehlman Committee investigation of the organization and administration of military R&D programs. He noted then that there was a tendency for the military to keep R&D at arm's legth and to ignore it in defense planning, largely because they failed to understand it. He explained that many of the great technological successes in World War II -- radar, the proximity fuse, and nuclear weapons -- were due to:[29]

> [T]he free-wheeling methods of outstanding academic scientists and engineers who had always been free of any inhibiting regimentation and organization. Every great research laboratory must strive to have men of this kind and to provide an environment analogous to that of the educational institution if it is to be really creative. The industrial companies that undertake pure research have found ways of doing this with great effectiveness.

The Services were sufficiently insensitive to R&D that even in 1954 he argued that significant technological advances were "piling up ... because our normal planning and decision-making processes cannot respond and make use of them as they become available."[30] Thus the Services were ignoring or driving away creative people and even when innovations did appear, they were soldom recognized or exploited.

During the Air Power hearings Killian was more explicit. He quoted the Hoover Commission conclusion* that the Services 'have not distinguished themselves in the initiation of radically new approaches or weapons systems' and explained it as follows: "[I]t could hardly be expected that the really radical approaches would come from within the Services. They must originate in the creative basic research that takes place in the universities and other institutions where the fundamental new ideas are most likely to be generated."[31] (Underline added.)

The idealization of basic research as the source of radical new ideas of military significance was virtually to become doctrine, incessantly repeated. There should be more basic research (fundamental ideas) and development (hardware). Killian defined basic research and its relevance to the military as follows:[32]

> ... I'm talking about the kind of research that in general is directed toward new concepts, new principles, rather than producing a piece of hardware. It is the yet unanticipated, unconceived discoveries which may determine our military strength tomorrow, and we must provide the environment from which such discoveries are most likely to come. If there are to be yet unimagined weapons affecting the balance of military power tomorrow, we want to have the men and the means to imagine them first.

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* The Second Hoover Commission on Organization of the Executive Branch reported in April 1955 that the Services were still living off contributions made by OSRD scientists during World War II and that the little they had done since was largely inspired informally by civilian scientists and technologists. The Commission believed the Secretary of Defense should take responsibility for insuring that radical new approaches to weapons systems were initiated and felt that he lacked a practical organizational framework for doing so. It recommended creation of a defense science board. (See Hoover Commission, Subcommittee Report on Research Activities in the Department of Defense and Defense Related Agencies, Task Force Report No. 11, April 1955, 82). Throughout the several organizational changes in DOD from 1947-1957, the evolution of approaches to R&D comprised a complicated set of modest moves from coordinating committees through boards, staff organizations, etc., that need not be traced here, other than to state that by and large they were unsatisfactory. It took Sputnik to uncork ARPA and, shortly thereafter, the Director of Defense Research and Engineering.

Killian noted that the Soviet Union was expanding its basic research and had "a great drive and determination, as a matter of national pride, to be champions in basic science as in other fields."

To beat the Soviets in the race for scientific and technological supremacy, it was necessary to train more scientists and engineers, achieve a higher degree of scientific literacy among the population, and improve the quality of our science. The key to training, education and quality lay in basic research. In addition basic research was the wellspring of advanced ideas. Thus the grossly inadequate level of support for this work needed to be increased. There was no compromising this view:[33]

> The future of the United States, to an extraordinary degree, is in the hands of those who probe the mysteries of the atom, the cell and the stars. Especially is this true of that tiny part of our creative effort which we inadequately term basic research.... Such a serious imbalance [in support for basic research] is a hazard to the economy, the safety, and the health of this country. If we are to continue to maintain an overall defense strength second to none, if we are to prevent Sputnik surprises in the future, we must augment this effort.

Thus ARPA was to be spawned in an environment which equated basic research with military security. Indeed, to do basic research was to be militarily "relevant." The President accepted this rationale and promoted it aggressively, starting with his policy address on "Our Future Security" a week after Killian's appointment. The result proved to be what Harvey Brooks later called, referring to the early 1960's, "The golden age of academic and basic research."[34] Above all, the Congress was very receptive to the linkage of basic research and national security. In 1954 the prestigious Riehlman Committee had in fact invented an "ARPA," on paper, to serve precisely that purpose. Its formal recommendation, after hearing a broad range of testimony from people such as Quarles, Trevor Gardner, Cyrus Eaton, von Neumann, A. D. Hill, Killian, and Vannevar Bush merits quotation in full:[33]

> The subcommittee notes that there is a serious need for the Department of Defense to support a systematic program of basic research in the physical sciences. Such a program might involve projects not particularly applicable to any immediately known military needs, or for that matter, to the needs of any of the service departments. Such a program might

> supply the basic knowledge upon which future weapons and weapons systems could be brought into being.
>
> The subcommittee is aware of the concept and policy adopted by the Office of the Secretary of Defense to keep that office from becoming an operating organization. It believes, however, that an exception to the rule is warranted by the great need for this type of support of basic research over and beyond that being provided and supported by the universities and the National Science Foundation.
>
> The subcommittee therefore recommends to the Secretary of Defense the advisability of initiating and supporting a systematic program of basic research directly through the Office of the Secretary of Defense with funds authorized for expenditure by the Assistant Secretary of Defense for Research and Development.
>
> The subcommittee has no preconceived ideas as to whether any or all of this work shall be carried out within the military departments for this Office. It is to be emphasized that these funds would be used for basic research not ordinarily initiated by the military departments; rather, they would supplement the work of the National Science Foundation.

Testifying before the Riehlman Committee, Killian opposed creation of a single civilian R&D organization in DOD because he felt it would never attract the appropriate leadership. Instead he proposed a great deal more contracting out of R&D work to civilian organizations that could attract high quality personnel. At the Airpower hearings in 1956 Killian endorsed the Hoover Commission recommendation that Assistant Secretaries for R&D be authorized in each Service, applauded the recently instituted IDA/WSEG arrangement (which he helped to create), and urged continued use of the ODM Science Advisory Committee by the National Security Council. He also said that it was:

> of very great importance that we have a research and development organization that can strike deep roots into our civilian scientific community and can tap our most basic and advanced research so that we are making available to military research and development with great rapidity the new developments which may be profoundly in-

fluential in new weapon technology.

Killian did not specify further what he meant by this remark and subsequently said that he could not claim to have had an embryo ARPA in mind.[36]

Killian's Air Power testimony developed other points of significance to the post-Sputnik period. The constant drumbeat of achieving excellence in science was soon elaborated into the "centers of excellence" concept. An argument was made for "flexible funding" in order to take advantage of new opportunities as they arose and to encourage innovation, both of which were alleged to be stymied in rigid military bureaucracies dominated by non-technical people. "Failures" were to be accepted as normal in R&D almost by definition. The need for long-term funding was emphasized, with specific reference to five-year programs in order to provide assurance of stable support. Even specific suggestions as to technical areas most urgently in need of support, e.g., materials and propellants, were to emerge later in the ARPA context.

Thus well before the Sputnik event, a rather coherent scenario had been constructed to explain it. The Soviets were making super progress in science and technology; training more scientists and engineers; supporting basic research heavily; innovating at accelerated speeds, in part because of the alleged benefits of a "monolithic organization;" and dedicating themselves to excellence in all things technical. The U. S. was deficient in trained people; on the verge of "mathematical illiteracy;" unappreciative of basic research; and ill-organized to deal with science and technology. The remedies were a massive commitment to education in general and scientific education in particular throughout the American school system; rapid elevation of basic research, in status and in level of support; recognition of the link between basic research and modern advanced weapons systems; overhaul of our organizational structure for conducting R&D, coupling R&D and technology with defense planning, and integrating science and technology into the mainstream of public policy; and a major voice for scientists in national life.

Of significance to ARPA, the President adopted virtually all the ideas on the scientists' agenda for action and articulated them in his major policy addresses in the immediate post-Sputnik period. Bronk observed that Eisenhower "liked to think of himself as one of us."[37] The Age of Science and Technology had arrived. Professionals who flew those colors "were treated with unusual deference by Congressional committees" as well and "were regarded with awe by public officials who professed ignorance in dealing with the technologically sophisticated problems."[38] Their influence was pervasive.

The prevailing mood at the White House was obvious. In general, the Services were felt to be idea-resistent, bureaucratic, wasteful, parochial, and basically incapable of "moving out." The President might have liked to wait a bit longer -- NASA, the Defense Reorganization Act and establishment of the post of Director of Defense Research and Engineering were to appear within a matter of months -- but "right now," it was essential to crack heads (or give the appearance of doing so) and provide almost instant evidence that the DOD was capable of managing itself and the nation's future effectively. The chosen instrument: an Advanced Research Projects Agency. In theory, at least, ARPA was seen "as a means and a willingness to take chances in a way that DOD had not been able or willing to do before."[39]

CHAPTER I: FOOTNOTES

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2. Ibid., 29.

3. National Science Foundation, Federal Funds for Research, Development and Other Scientific Activities, Fiscal Years 1972, 1973 and 1974, Volume XXII (NSF 74-300).

4. Dwight D. Eisenhower, "The Free World Challenged by Communism: We Must Have Unity and Faith." Alfred E. Smith Memorial Foundation dinner address. New York, October 16, 1952.

5. Senate Committee on Armed Services, Subcommittee on the Air Force, Study of Airpower, Hearings, 84th Congress, 2nd Session, June 1956, 1172 and 1180.

6. These points, and some others in the Airpower Hearings testimony, were also made by Killian in an address to the Institute of Aeronautical Sciences in January 1956. See Aviation Week, January 30, 1956, 26-27.

7. Senate Committee on Armed Services, op. cit., 1187.

8. Herbert F. York, Race to Oblivion: A Participant's View of the Arms Race (New York: Simon & Schuster, 1970) 157.

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10. Joseph & Stewart Alsop, The Reporter's Trade (New York: Reynal, 1958) 328-329.

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12. York, op. cit., 11.

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16. Green and Lomask, _op. cit._, 190.

17. Senate Committee on Armed Services, Preparedness Investigating Subcommittee, _Inquiring into Satellite and Missile Programs_, Hearings, 85th Congress, 1st Sess., 1957, Part I, 301-2.

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19. Dwight D. Eisenhower, "Our Future Security," Radio and Television Address, November 13, 1957.

20. Charles J. V. Murphy, " The White House Since Sputnik," _Fortune_, January 1958, 100. See also Gilpin, _op. cit._, 171.

21. Quoted by R. Cargill Hall, "Early U. S. Satellite Proposals," in _Congressional Record_, October 7, 1963, A6279.

22. Green and Lomask, _op. cit._, 32.

23. _Ibid._

24. Eisenhower, _Waging Peace_, 206.

25. Green and Lomask, _op. cit._, 202 and Eisenhower, _Waging Peace_, 210-11.

26. David Z. Beckler, "The Precarious Life of Science in the White House," _Daedalus_, Summer 1974, 118.

27. Sherman Adams, _Firsthand Report_ (New York: Harper, 1961) 415. See also Murphy, _op. cit._, 100-01; Eisenhower, _Waging Peace_, 211-12; Beckler, _op. cit._, 117-119; Detlev W. Bronk, "Science Advice in the White House," _Science_, October 11, 1974, 116-21; and Bronk, "The National Science Foundation: Origins, Hopes and Aspirations," _Science_, May 2, 1975, 409-14.

28. Senate Committee on Armed Services, _Study of Airpower_, Hearings, 1186-87. Unless otherwise cited, the remainder of this section is based on the Killian testimony in these hearings, 1171-1207.

29. House Committee on Government Operations, Subcommittee on Military Operations, Organization and Administration of the Military Research and Development Programs, 83rd Cong., 2nd Sess., June 17, 1954, 429.

30. Ibid., 432.

31. Senate Committee on Armed Services, Study of Airpower, Hearings, 1183.

32. Ibid., 1179.

33. James R. Killian, Jr., "The 'Growing Edge' of Innovation," Address to the Economic Club of Detroit, February 23, 1959. See Vital Speeches, April 1, 1959, 375-76.

34. Harvey Brooks, "Are Scientists Obsolete?", Science, November 8, 1974, 501.

35. House Committee on Government Operations, Subcommittee on Military Operations, Organization and Administration of the Military Research and Development Programs (Report of the Riehlman Committee), 83rd Cong., 2nd Sess., April 4, 1954, 10.

36. Discussion with Dr. James R. Killian, Jr., May 8, 1975.

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39. Discussion with Dr. Charles Townes, July 10, 1975.

Chapter II

THE DOD MOBILIZES

TOWARD A "SPECIAL PROJECTS AGENCY"

Sputnik occurred at a time when the DOD was undergoing a changing of the guard. Secretary Wilson, a consistent opponent of satellite programs as "scientific boondoggles,"* had recently resigned. His replacement, Neil McElroy, was sworn in on October 9, 1957, just five days after Sputnik. Indeed on the very day Sputnik was launched the Secretary-designate was visiting ABMA at Huntsville as part of a routine familiarization tour of military facilities before taking office. Wernher von Braun, Army Secretary Brucker and Generals Gavin and Medaris used the occasion to make a dramatic appeal for unleashing the Army in space.[1] Clearly outer space was at the forefront of the new man's thinking in his earliest days on the job -- there was no way to escape it.

An experienced corporate executive with a strong sales and public relations background, McElroy was a novice in government. The Pentagon was extremely tense when he arrived. Largely as a result of the scientific breakthroughs in weapons systems, unsettled Service roles and missions disputes were at fever pitch. Wilson, for instance, had left unresolved the question of whether the Air Force Thor or the Army Jupiter intermediate range ballistic missile (IRBM) should be approved for production. The new vistas opened up by the advent of space further exacerbated Service rivalries. The Services felt that nothing less than access to the weapons systems of the future was at stake, i.e., their very survival. To be left out, especially given Eisenhower's budget stringency, could mean permanent degradation. In the absence of decisions about ultimate assignment of missions and advanced systems, each Service fought to develop such systems in its R&D program in hopes that the successful "inventor" might have the inside track for designation as ultimate user. The in-fighting was fierce, its intensity matched only by Eisenhower's anger over the Services' inability to overcome their mutual suspicions.

McElroy Debates the Alternatives

McElroy invited the Services and some senior staff to advise him on how best to cope with the new dimension of outer space. The Air Force and Army each staked out a unilateral claim to the space mission. Air Force enthusiasts spoke of creating a new Aerospace Force. The Navy considered outer space over the oceans a natural extension of the ocean underwater, surface and air regime in which it operated. Army proponents spoke earnestly

* Wilson practiced the doctrine of "relevance" in a pure form. R&D budgets were starved during his stewardship because research projects had to be shown to be directly relevant to a military mission in a very strict sense.

of the moon as "the high ground" and felt that the Army should be commissioned to "take it." The Secretary thus soon realized that he could not readily choose between the contending Services.

The Navy, having no chance at the whole pie, argued diplomatically for a new tri-Service enterprise analogous to the Armed Forces Special Weapons Project (AFSWP), that would report to the JCS* (this agency had conducted the military nuclear weapons program, using the system of rotating Service appointees as directors). While the Navy's proposal was interesting, the AFSWP experience was not appealing because there had always been Service bickering within it. With Service roles and missions unsettled, such an organization would not be able to develop a coherent, single space program.

William H. Holaday, making a bid on behalf of his Directorate for Guided Missiles, endorsed the Navy's tri-Service approach in principle, but suggested that the name be changed to Armed Forces Missiles Projects Group and that it report to him through a Special Deputy. Referencing the President's November 7 speech, which had instructed the Secretary to make certain that the Director for Guided Missiles be "clothed with all the authority that the Secretary himself possesses" in the missile field, Holaday specifically recommended that the Secretary create the new organization:[2]

> ... to handle two new projects of importance at the present time. These are the anti-intercontinental ballistic missile and the reconnaissance satellite. Since both of these projects cut across the interest of all three Services and the current approaches are causing duplication, it appears that these programs must be directed in such a manner to use the best talents of the three Services and industry.

The organization he foresaw would initially use money in Service budgets until a separate appropriation could be secured and plan and coordinate work that would be carried out by the Services and industrial contractors. Its modus operandi would be similar to AFSWP's.

The Holaday solution, like the Navy's approach, had appeal but faltered on past organizational experience. The various special assistants for guided missile work had never been able to do more than roughly coordinate Service

* Each Service presented its case to the Secretary at a meeting of the Armed Forces Policy Council (AFPC) on November 5, 1957. Admiral John E. Clark, who was to become the first Deputy Director of ARPA three months later, gave the Navy's presentation. The Navy approach was of sufficient interest to the Secretary that all AFPC members were asked to comment on it. Admiral Clark maintains that all the Service approaches were sent to the President, who liked the Navy's idea the best, although not the reporting line to the JCS. (Discussion with Admiral Clark, July 8, 1975.)

missile activity, and Holaday personally was not considered strong enough for the job. The same view was held of the Assistant Secretary for Research and Engineering. One of the previous incumbents of the latter office testified that his "authority was denied and opposed principally by one of the military departments, and my activities were impeded by the refusal by the military departments to furnish pertinent information about individual development projects."[3] The Defense Science Board had rebelled against the inadequacies of another Assistant Secretary.[4] Traditional OSD staff offices simply appeared unable to cope with the Services.

Numerous suggestions were being made in other quarters. The Atomic Energy Commission, promoting nuclear propulsion systems, lobbied very hard to get the space mission away from Defense, and the Chairman and Deputy Chairman of the Joint Atomic Energy Committee moved quickly to introduce bills to establish by law an Outer Space Division within the Commission.[5] Some scientists suggested recreating the World War II Office of Scientific Research and Development. Others revived the Manhattan Project concept, a recurring and popular idea whenever emergency situations arose. Charles Thomas, the President of Monsanto Chemical, and the eminent nuclear physicist Ernest O. Lawrence discussed this option for space directly with McElroy, but he rejected it as infeasible in peacetime.

Thomas and Lawrence visited McElroy to urge him to adopt some radical new measures to organize the Department to meet the Sputnik challenge, and to cope better with problems of science and technology in the Defense Establishment. The three men went over a wide array of possibilities in the course of a several hour meeting.[6] During that session, the concept of a strong advanced R&D agency reporting to the Secretary emerged and Thomas and Lawrence urged it strongly on the Secretary. McElroy was enthusiastic about it. Thomas says that he does not know for sure if he and Lawrence were the first or the only people to make the suggestion, but they did make it. Perhaps they merely confirmed McElroy's own predilections. Roy Johnson said on several occasions that McElroy had set up a small research group reporting directly to him at Proctor and Gamble that did "blue-sky research."[7] Apparently this group had come up with some good money-makers for the company, especially in the packaging area, and he was comfortable with such an organization. This experience could very well have been the ultimate source of the ARPA idea or helped shape it.

Throughout this period McElroy consulted frequently with the President and with Killian, whom he had known previously when both served on a national advisory group concerned with education. The President was so taken with the views expressed by Killian and other Office of Defense Mobilization Science Advisory Committee scientists at the October 15 meeting noted in the preceding chapter that he dispatched them that very day to repeat their story to McElroy, Quarles, JCS Chairman Twining, and other senior personnel at the Pentagon, where they "added some very pointed comments on the desirability of a more sophisticated relationship between the military and science."[8

This was a theme long espoused by Killian, as noted earlier, but was now receiving explicit Presidential endorsement. Pressure continued to mount on the White House to "do something," especially after Sputnik II (1120 lbs.) was placed in orbit on November 3, and the White House in turn leaned hard on the new Secretary. Killian confirms that neither he nor anyone else at the White House "invented" ARPA; however, when McElroy broached the idea, the White House gave it every encouragement.[9]

The Secretary Decides

On November 6, 1957 -- the day following the Service presentations to the Armed Forces Policy Council -- McElroy asked his General Counsel (Robert Dechert) for answers to four critical questions which eventually served as the benchmarks for ARPA's creation. The subject of the General Counsel's memorandum, "Central Control of Anti-Missile Weapons and Satellites," makes it clear that the Secretary had already decided what the new organization would do, if he could establish it. The Secretary's questions, which show that he was thinking beyond conventional approaches, were:[10]

1. Does the Secretary of Defense have legal authority by transfer of functions to establish, in his office under an Assistant to the Secretary, a new unit which would centralize control of activities in the field of anti-missile weapons and satellites?

2. Are there any immediate steps with respect to the Congress to be taken in connection with the directive which would carry out the foregoing?

3. Can appropriations to the military services be made available for expenditure under the direction of your Assistant who is placed in charge of the field referred to above?

4. Does this newly created organization have to be completely self-contained or may it call on the military departments to perform administrative functions such as the preparation and signing of contracts, disbursement of funds, and other support activities?

Dechert's responses were positive. The Secretary did have authority to set up such a special unit; he would have to notify the Chairmen of the Armed Services Committees in accordance with a provision of the National Security Act of 1947, but no legislation was necessary; several methods existed for making Service appropriations available for expenditure under the Secretary's direction (indeed the $34 million FY 1958 Vanguard budget was already subject to his direct control); and there was ample authority and precedent for having the Services perform administrative functions for the new organization, subject to its control. McElroy ordered that a letter for the two Committee chairmen be drafted under Dechert's guidance. He had decided to move ahead.

On November 20, McElroy testified on the Hill for the first time as Secretary. Although the main purpose of the hearing was a ballistic missile investigation, the Secretary disclosed that he was about to set up a new "single manager" to do the R&D on future weapons systems, beyond the guided missile. He called it the Special Projects Agency (SPA):[11]

> We plan to establish in the Department of Defense a special agency to handle our satellite and space research and development projects. Tentatively we are thinking of calling this -- and this has not been announced -- the Special Projects Agency of the Department of Defense. We plan to assign to this agency all of our effort in the satellite and space research field. In addition, it appears that we might wish to have this agency direct and manage the Department of Defense program in the antiballistic missile field. Other projects and programs may also be assigned from time to time. What we have in mind for that agency is that <u>the vast weapon systems of the future</u> in our judgment <u>need to be the responsibility of a separate part of the Defense Department</u> that has a responsibility that is inescapable in order to follow these various will-of-the-wisps -- if they are originally in that kind of state -- and carry them through to a point where there can at least be a determination of their feasibility and what their probable cost might be. So we are thinking of this Special Projects Agency as having a function that extends beyond the immediate foreseeable weapons systems of the current or near future. (Underline added.)

The next day McElroy circulated to the Services and JCS a proposed charter for the SPA. It was to be headed by a director reporting directly to the Secretary and staffed by civilian and military personnel as he saw fit.

The Services were adamantly opposed to the idea. Quarles was not enthusiastic about it either.[12] As the former Assistant Secretary for R&D and overseer of Vanguard, he could be expected to be defensive about changing the direction of satellite programs and to oppose additional fracturing of the OSD R&D apparatus. The suggestion to create an ARPA was more than just an implied criticism of the existing structure. Apparently another key figure in OSD, Comptroller Wilfrid McNeil, was also opposed, but he remained relatively silent on the issue out of recognition that Eisenhower's personal anguish over interservice rivalries was bound to result in some sort of a new centralized agency.[13] In brief, McElroy found remarkably little support inside DOD for his Special Projects Agency.

In order to appreciate the significance of the mere act of creating an ARPA, it is necessary to recall the state of defense organization and behavior which prevailed at the time. Many of the concepts or phrases used to justify ARPA -- prevention of wasteful duplication, parochialism, inefficiency, Service rivalry, disunity, failure to coordinate, overlapping jurisdiction, etc. -- were in fact familiar terms in a debate over the most effective organization of the defense establishment that had persisted from the end of World War II. The 1940's and 1950's were suffused with such arguments. Given a background of vivid wartime experiences, growing Cold War tension and the "balance of terror" aspects of nuclear weapons, it is not surprising that the Congress, the President, and concerned Executive Branch agencies devoted a great deal of attention to defense organization. The Department of Defense itself was created only in 1947. Major reorganizations were negotiated by Congress and the President in 1949, 1953 and 1958, each designed to strengthen Secretarial control vis-a-vis the military departments. The latter resisted tenaciously. Attempts at organizing properly for research and development were included, but were by no means central issues prior to 1958. Service challenges to the Secretary's authority were frequent and the Office of the Secretary was a relatively weak collection of staff offices. While Sputnik was a completely new phenomenon, the notion of consolidating control in the Secretary's hands was not. Hence McElroy's initiative aroused instinctive opposition.

McElroy's trump card was the President. General Eisenhower came out of World War II with deep convictions about the value of a unified military. In the emotional debate which preceded passage of the National Security Act of 1947 he had recommended creation of a single Service. Upon assuming the Presidency he became a crusader against waste and duplication in the military. Eisenhower was greatly annoyed by Service competition for missiles and access to nuclear materials, which invariably resulted in huge budget requests. The Army and Air Force "race" to build almost duplicate IRBM's incensed him. Sherman Adams has said that the President actually favored putting all R&D projects under the Secretary of Defense.[14] Exactly that recommendation was made by the U.S. Chamber of Commerce to the House Appropriations Committee in May 1957, and the press speculated subsequently that it had been promoted at the White House and played a role in the decision to establish an ARPA.[15] The President also was irate over Service end-runs to the Congress in order to promote higher budgets. His temper often flared on these issues, and he caused an absolute furor in the Pentagon by demanding that the three Services merge their highly promotional information offices into one.[16] According to Killian, fragmentation of R&D in DOD and the severe tri-Service conflicts were "one of the things that troubled Ike most during his Presidency ... he was always indignant about the internecine struggles in DOD."[17]

When the space race began, Eisenhower was determined to prevent duplicate or triplicate military space programs. This rapidly became accepted as an article of faith among the men engaged in organizing for space and the President's personal stamp seems to be on most of them. As noted above, minimization of interservice rivalry was given in his November 7 speech to the nation as a basic criterion for creating Killian's position, attempting to upgrade the Holaday office and announcing that future missile and space projects would be "separately administered." In another major policy address to the nation a week later, the President discussed satellites and their cost, noted that military space projects would be judged against the value of competing defense projects, and pledged that there would be "no needless duplication or obsolete programs or facilities."[18]

Buttressed by strong Presidential support, McElroy's draft Special Projects Agency charter thus promised to strengthen enormously OSD's role in research and development. The Secretary's proposal included the following: (Underlines added.)[19]

1. SPA's purpose was to provide "unified direction and management of certain research and development projects."

2. It would "direct, manage, enter into contracts for, or operate such projects" as the Secretary designated.

3. It would be authorized to perform work in its own facilities (laboratories) and let contracts, as well as arrange to have work done in its behalf by the Services and other agencies, "within the limits of appropriations available."

4. The OSD Comptroller would "make arrangements for funding the operations of the Agency."

5. SPA would develop its assigned programs "to the point of operational use," whereupon "they would be phased into the operation of one or more of the military departments."

The Secretary's testimony before the Mahon Subcommittee gave the Services additional context within which to consider his proposal. It left no doubt that his thinking was very expansive, and hence very threatening. As noted above, he stated that SPA would be assigned responsibility for "the vast weapons systems of the future." Further questioning elicited the opinion that he planned, in SPA:[20]

> to centralize the research and development of a weapons system or group of weapons systems which do not have any obvious service connection in their inception. We plan to use this agency for the purpose of carrying those weapons through the research and development stage. That means quite far down the road, including testing.

Missiles aside, he was prepared to put "any further things of an upstream nature," and "things in general," in SPA. He asserted that a new man from outside DOD would be brought in to head it. Putting the research, development and test of dramatic, new, advanced weapons systems -- which everyone assumed would be forthcoming -- in the hands of an OSD level agency was anathema to the Services. Among other things it had tremendous funding implications, especially given Eisenhower's demonstrated insistence on hold-the-line budgets: whatever SPA received meant less money for the Services and perhaps their contractors, and as work proceeded through development to test these sums became immense. And it suggested that Service opportunities to influence the assignment of roles and missions -- decisions that controlled which of them would have access to the most modern weapons systems -- would be greatly weakened. One could scarcely make a more threatening gesture.

The Counterattack

When the Secretary of the Air Force replied to McElroy's request for comments on the proposed Special Projects Agency he acknowledged forthrightly that:[21]

> The Air Force appreciates that the subject proposals are suggestions and implementation of Presidential policies for better and improved directional management in relation to certain areas of research and development.

The message had been received, but still was not accepted by the Services. They chose to fight.

The Services and JCS had their responses to the draft SPA charter* back to McElroy in two days. Aviation Week predicted "violent protests" from the Services and reported that industrial contractors were apprehensive, fearing that SPA might set up in-house laboratories -- the "arsenal" system -- which they opposed for obvious commercial reasons.[21] Aviation Week's protest estimate was accurate.

The Services were not happy with the SPA idea or the draft charter, but with the President's outlook common knowledge and the Secretary

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* Two documents were circulated, a draft DOD Directive and a draft letter to Armed Services Committee Chairmen Russell and Vinson.

discussing his intentions publicly, their first gambit was to try to constrain it or cut it back. Their charter comments reflect this.

With respect to SPA's purpose, the Army, Navy and JCS proposed in their comments to the Secretary that it be limited to unified direction of the satellite and anti-ICBM projects only and they deleted all reference to the possibility of other future assignments. In fact, Navy recommended re-naming the agency the "Space Vehicle and Ballistic Missile Defense Agency" to emphasize the limitation. Only the Air Force was prepared to concede that in the future the Secretary might assign SPA "appropriate projects which this Agency can perform more expeditiously than under present procedures."

Second, the three Services and JCS went to great pains to delete all use of the words "management" and "operate" or "operation." It was all right for SPA to "direct" a program, but management and, above all, operation implied a function that carried too far beyond the conventional staff role of OSD. The notion of an executive agency in OSD was most unacceptable, especially one that might monopolize entree to the modern weapons systems of the future. As far as the military departments were concerned, they were the only authorized operating agencies in DOD. Even the references to SPA taking projects up to the "point of operational use" and then phasing them into the Services were deleted or heavily conditioned. Navy suggested saying instead that "as military equipment evolves from the programs it will be incorporated in weapons systems." JCS and Army said that SPA programs:

> ... will be developed in coordination with the appropriate military Services. This will ensure that the long lead time connected with training, procurement of ground handling equipment, bases, etc., is coordinated with the development effort so as to phase new weapons into the operation of one or more of the Services....

Army, Air Force and JCS also sought to introduce language in the charter which avoided mention of SPA-owned facilities and all four respondents proposed changing SPA direct contracting authority to merely an authorization to contract through the Services. In addition, the JCS and Army were very alert to the imprecision in the Secretary's charter language about the source of funds for SPA (see items 4 and 5 above, p. II-7). They wanted to change "within the limits of appropriated funds" to "assigned funds," i.e., SPA was to get its own money, and JCS, Army and Navy sought to redirect the Comptroller's function from "making arrangements for funding the operations" of SPA to simply supervising the fiscal policies and management of the Agency's activities.

All but one of the respondents made textual deletions, additions and modifications without explanation. Air Force Secretary Douglas was the exception, and he provided a succinct statement of the Service case:

> [I]t would seem that the proposed directive itself has a breadth which does not correspond to present intentions. Through its inclusion of direct authority to "enter into contracts" and to "operate" it would seem to provide for what would virtually amount to an operating development agency involved in procurement and operation of laboratory and other facilities. This would constitute a step towards a self-contained research and development agency without the close association with prospective users that is so important. We believe that any such step should be further appraised in view of its possible ultimate consequences and that initially the directive not be so broadly designed.

The Service/JCS objections to the initial SPA draft were considered in OSD, but for the most part rejected. Assistant Secretary for Research and Engineering, Paul Foote, reconfirmed, in opposition to Douglas' remarks, that McElroy's directive did correspond to present intentions and said that he viewed SPA "as a step toward a centralized research department in the same manner that many corporations utilize a centralized research department reporting directly to the President on problems of interest to the Corporation as a whole," while at the same time permitting other departments to have their own R&D units -- precisely what the Services hoped to head off.[22]

Sometime during the period November 21 to November 29, the "Special Projects Agency" was rechristened the "Advanced Research Projects Agency."* That name appeared in a revised version of the charter which the Secretary's Military Assistant, BG C. M. Randall, USMC, sent to the Services and JCS on November 29 in anticipation of a meeting with the Secretary. Written comments were not requested, but JCS, Navy and Air Force felt strongly enough to submit them anyway.

The revision conceded some points to the Services, but the Secretary was adamant on two issues:[23]

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* Rep. Scrivner objected to "Special Projects Agency" because it was easy to confuse with other agencies (e.g., OSD Office of Special Operations and the Armed Forces Special Weapons Project) and McElroy promised he would select a better one: "We are trying to make it broad enough in terminology so that the tent can cover additional projects as they come along and give evidence of some future potential." (House Appropriations Subcommittee on Defense Appropriations, "The Ballistic Missile Program," Hearings, November 20-21, 1957, 25.) L. P. Gise believes that Lt. Col. George Brown, USAF, a military assistant in Holaday's office, actually came up with the name ARPA. (Discussion with L. P. Gise, April 7, 1975.)

> The Secretary of Defense wishes to make it clear that while the Agency will normally contract for research and development through the existing channels within the Military Departments, he intends to authorize the Director of the Agency to have contracting authority to the extent required and where direct contracting would better serve the purposes of the Agency. The Secretary also wishes to have it understood that additional projects other than satellite applications and antiballistic missiles programs may be assigned to the Agency in the future.

The Secretary dropped virtually all use of the word "operate," in deference to Service sensibilities, and replaced it with "manage."* He also made no reference to how the Agency would be funded. Navy fought a rear-guard action by proposing the charter say that ARPA's R&D work would "not infringe upon the existing research responsibilities" of the Services and would be "restricted to those areas novel in nature and not normally conducted by the military departments," i.e., to as little as possible.[24] Navy also called for language directing ARPA to do both its contracting and its laboratory work through the Services "to the maximum extent possible," in preference to setting up "new or separate facilities."

JCS was so embittered that it registered a formal written nonconcurrence on December 6, 1957. The Chairman, General Twining, complained that since the drafts still contained "some basic provisions" which the Chiefs considered "inadvisable," he wanted the Secretary to remove any indication of JCS concurrence in the establishment of ARPA from the letter to the two Armed Services Committee chairmen.[25]

The Air Force also took a very harsh line. Secretary Douglas protested that it was neither necessary nor desirable for ARPA to have contracting authority because the Agency would establish a new administrative organization and confuse existing relationships between DOD and industry. Douglas promised that Air Force would "simplify its own lines of authority for projects under the Agency's direction," to include eliminating intermediate echelons of authority between the project officer and the Chief of Staff.[26] He recommended that the Secretary eliminate the ARPA Director's authority "to contract or directly operate through his own personnel research and development projects."

Next, Douglas gave a ringing endorsement of the Air Force doctrine of concurrency, namely, that the Service which is to use a weapons system should be in charge of its development from the very inception of the system. In any multi-user situations, he insisted that "the potential users must be staffed to express their requirements and present their

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* "Manage" was a word used by Chairman Vinson of the House Armed Services Committee to define the meaning of the Secretary's "control" over DOD during a 1949 debate on the National Security Act.

suggestions during development ... development in close identity with the user or users is a necessity." Accordingly, it was suggested that the ARPA Directive be modified so as to identify the user of a weapon placed under ARPA direction and to "permit the user a subordinate control of the project or, if more than one user be involved, one user or the users jointly carry on the project as the Director may determine under his continuing direction."

Third, the Douglas memorandum fumed about the proliferation of over-seers at the OSD level and foretold a future in which the Director of Guided Missiles, Assistant Secretary for Research and Engineering and Director of ARPA would all be issuing instructions on the same project to a harassed military department. It was observed that "administrative efficiency and decision making would be much further advanced if the Director of the Agency were given exclusive authority in whatever area is finally determined" and the Secretary was lectured to include in the ARPA directive language making clear that "within such area of direction and authority as is granted [to the ARPA Director], other members of your staff be excluded from the authority of direction that they increasingly exercise."

Finally, the Secretary was informed that he could not legally endow ARPA with the right to let contracts or to establish laboratories because he lacked the power. In Air Force eyes, the proposed action was Secretarial interference in a preserve statutorily reserved for the Services alone. The Air Force opinion proceeded to tell the Secretary what he could and could not do:

> If the new office establishes laboratories or contracts itself for research services, essential operating functions of the military departments would be transferred for the first time to a separate agency in the Office of the Secretary of Defense. This would seem to be contrary to the intention of Congress as expressed in the National Security Act and other legislation. That intention clearly appears to have been that the Office of the Secretary of Defense make policy and provide authoritative coordination and unified direction of the Armed Services, and that the military departments be the operating agencies of the Department of Defense. The Secretary of Defense has been directed by Congress to "coordinate research and development among the military departments and allocate responsibility for specific programs among the Departments;" but only the military departments have been specifically vested by statute with authority to conduct and participate in research and development programs relating to the Armed Forces and to undertake procurement actions in connection therewith.

The Air Force advised the Secretary to withhold assigning such powers to the ARPA Director until the matter could be resolved "by clear legislative authority."

Recognizing that McElroy was digging his heels in, the military rolled out their siege guns in December. While the Secretary was in Europe attending a NATO Council meeting and touring military bases, the Air Force set up a new Directorate of Astronautics and transferred to it all Air Force missile defense work, the Air Force satellite projects collectively known as Weapons System 117L, Air Staff management of Lincoln Laboratories, some research satellites, boost glide vehicle research, and special reconnaissance aircraft. It was a bold move to put a mini-ARPA, emphasizing space and missile defense, on the street before McElroy could act. When Quarles heard about it, he ordered that public announcement be held up, but the full story was leaked quickly to the press. General Gavin and other Army officers chimed in with strong statements about the importance of space control to the Army's land mission. The ARPA concept was ridiculed in the press as a "paper-bound idea" and news about Service opposition to the draft charter was disseminated rapidly.[27] Former Navy Secretary Dan Kimball, speaking as President of Aerojet-General Corp., launched a bitter attack on McElroy's portrayal of ARPA, arguing that such "double management" would result in duplication of effort and cost, delays, and inferior end products.[28] Air Force Secretary Douglas and his senior military R&D officers then publicly opposed creation of ARPA in testimony before the Senate Preparedness Subcommittee, immediately after McElroy forced them to withdraw establishment of the Astronautics Directorate. Douglas was prepared to concede ARPA a role in basic research, but "once you move over the poorly defined line to applied research, I would object."[29] The Air Force generals were even less kind, opposing the creation of more committees, czars and directors, and specifically ARPA. General Schriever, a consistent ARPA opponent for years to come, told the Subcommittee that he wanted to register "a strong negative against ARPA. This would be a very great mistake."[30]

The ARPA Concept is Validated

The December onslaught failed. As Admiral Clark observed, "The fact they didn't want an ARPA is one reason Ike did."[31] On January 7, 1958 the President sent a message to Congress forwarding a request for $10 million in FY 1958 funds:[32]

> For expenses necessary for the Advanced Research Projects Agency, including acquisition and construction of such research, development, and test facilities, and equipment, as may be authorized by the Secretary of Defense, to remain available until expended.

Then the President drove his point home in the State of the Union Message, January 9, 1958. The advent of revolutionary new devices, he said, was causing defense problems at least as significant as those created by invention of the airplane fifty years previously:

> Some of the important new weapons which technology has produced do not fit into any existing service pattern. They cut across all services, involve all services, and transcend all services, at every stage from development to operation. In some instances they defy classification according to branch of service.
>
> Unfortunately, the uncertainties resulting from such a situation, and the jurisdictional disputes attending upon it, tend to bewilder and confuse the public and create the impression that service differences are damaging the national interest.... I am not attempting today to pass judgment on the charge of harmful service rivalries. But one thing is sure. Whatever they are, America wants them stopped.

The President added that he would shortly submit to Congress major reform legislation intended to achieve "real unity in the Defense establishment in all the principal features of military activities." In the interim, he was prepared to take some immediate steps to obtain better integration of resources applied to the newer weapons. One such step was to state that:

> In recognition of the need for single control in some of our most advanced development projects, the Secretary of Defense has already decided to concentrate into one organization all the anti-missile and satellite technology undertaken within the Department of Defense.

This affirmation of McElroy's decision to establish ARPA was accompanied by a stern Presidential warning to the Services to stop the open warfare: "Another requirement of military organization is a clear subordination of the military services to duly constituted civilian authority. This control must be real; not merely on the surface."

A second step taken by the President was acceleration of effort in "particular areas affected by the fast pace of scientific and technological advance." He listed seven such areas, including the charge to "be forward-looking in our research and development to anticipate and achieve the unimagined weapons of the future."

In the event the President needed any additional support for these views, the Rockefeller Brothers Report on International Security: The Military Aspect was released the same day as the State of the Union

Message. It also found the Services' roles and missions inconsistent with modern technology and argued forcefully that the Secretary spent most of his time serving passively as referee and arbitrator for inter-service disputes at a time when conditions warranted activitist Secretarial leadership and direction. As part of a series of recommendations designed to transform the Secretary into a more aggressive posture as initiator and controller of events, the Report proposed assigning the Secretary: (1) direct authority over all R&D and procurement, (2) right of cancellation and transfer of Service programs and their appropriations, and (3) "a direct appropriation for the conduct of research and development programs at the Defense Department level."[33] The last, of course, was interpreted as a direct endorsement of ARPA, and the Report's rationale for making all these recommendations could have served as the Agency's motto:

> Where so much depends on keeping up and staying ahead in the technological race, it is essential that our weapons development reflect a clear sense of direction and not a series of compromises.

The day after the State of the Union Message General Schriever returned to the Senate Preparedness Subcommittee to assail the plan to establish ARPA. In what New York Times Pentagon reporter Jack Raymond called "a puzzling departure from usual practice," the Air Force released his testimony the next day rather than wait for the Subcommittee to do so.[34] Schriever's theme again was that ARPA would simply waste money duplicating work that had already been done elsewhere.

Undeterred, the President followed up with explicit reference in his FY 1959 Budget Message (January 13, 1958) to the provision of funds for "an expanded research and development effort on military satellites and other outer space vehicles, and on antimissile missile systems, to be carried out directly under the Secretary of Defense."

The Legal Niceties

Despite the President's firm support of ARPA, neither the Directive nor the Agency itself materialized in December or January. This was due to a tug-of-war between the Department and Chairman Vinson over the Secretary's authority to establish an operating agency independent of the Services without specific new legislation, a situation exacerbated by Departmental insensitivity to the Vinson Committee's legislative prerogatives. Thus the dispute was a mixture of principle, Executive-Legislative Branch etiquette, and the Armed Services Committee's ever-solicitous attentiveness to the views of the military. There was some correspondence between the Committee's objections and the Air Force's challenge to McElroy's legal authority, but the tenor of the Vinson complaints seemed less due to a desire to kill ARPA than pique that the Administration was trying to ride roughshod over the Committee. In any event, the record indicates that there was considerable apprehension in OSD for awhile that the invincible Chairman might kill the whole idea.

As noted earlier, the President sent an appropriations request to the Hill on January 7, 1958 for funds to cover ARPA expenses, including acquisition and construction of such R&D facilities as the Secretary authorized. The latter phrase proved to be a bone in the throat of the Armed Services Committee. McElroy testified on the bill before the House Appropriations Committee the next day. Since it was the DOD view that the Secretary could establish ARPA under existing authority, and endow it with contracting authority and the right to acquire facilities, no thought was given to the need for special authorizing legislation. The House Armed Services Committee saw it differently and was especially annoyed that unless it acted, the appropriations bill would de facto serve as authorization both for ARPA and for ARPA spending on construction. In other words, they were incensed at the apparent attempt to finesse the Committee's rightful authority. Robert Smart of the Committee staff stated the Committee's particular concern tartly:[35]

> We have in this supplemental appropriation bill, language which in my judgment, in the absence of any other authority of law, will give them the authority to engage in this kind of construction. This is a point which has always been an extremely sore point with this committee and other legislative bill. And the urgency of the moment, with reference to this Agency, does not alter in any manner the character of that situation.
>
> So I think the committee has to face this point: are we going to stand by and have the Appropriations Committee report a bill containing the sole authority at law to build these defense research and testing facilities, or is this committee, in the discharge of its legislative responsibility going to insist that this committee handle the legislation which would confer this authority?

Aggravation over this apparent challenge to the inherent privileges of an authorizing committee probably had more to do with the Committee's displeasure than any broader philosophical concerns about Secretarial authority vis-a-vis the military departments. The Armed Services Committee simply was adamant that McElroy not obtain funds from the Appropriations Committee that he might then use on unspecified construction projects that had not been specifically blessed by it.

Nor was the Committee prepared to consider the ARPA request a routine matter. Smart reminded McElroy that this was the first instance in the eleven year period since enactment of the National Security Act that DOD had "ever proposed to go beyond policy, direction, guidance and control, and enter into the operational field."[36] They were not about to be snowballed.

Thus the Vinson challenge focused on two assertions: (1) that the Secretary lacked legal authority to create an ARPA at all, and (2) that he lacked legal authority to build facilities for ARPA, unless he succeeded in cadging such authority indirectly by his apparent end-run to the Appropriations Committee. With respect to the first point McElroy and Dechert argued that the Secretary had complete authority under the National Security Act, as amended, to establish ARPA.[37] Dechert even quoted liberally from Chairman Vinson's remarks during past debates over the National Security Act, including the following definition of the Secretary's legal power to "control" DOD made by Vinson in 1949:[38] "'Control' means power or authority to manage, direct, superintend, restrict, regulate ... govern, administer, or oversee." Dechert also relied heavily, in a lengthy brief prepared for the Secretary, on the conclusions of the Counsel to the Committee on DOD Organization (Rockefeller Committee) which were part of the legislative history of Reorganization Plan No. 6(1953). Speaking of the Secretary's authority under the National Security Act, as amended, the Counsel had said:[39]

> ... the power and authority of the Secretary of Defense is complete and supreme. It blankets all agencies and all organizations with the Department; it is superior to the power of all other officers thereof; it extends to all affairs and all activities of the Department; and all other authorities and responsibilities must be exercised in consonence therewith.

Discussion about the Secretary's right to give ARPA authority to acquire facilities became exceedingly convoluted, and Dechert's defense was especially lame,* but it appears that both sides finally concluded that any ARPA construction would have to be specifically requested in a military construction authorization bill.

No such agreement was reached on the broader issue of the Secretary's power to create ARPA and on January 15 Vinson sponsored an amendment to the authorization bill that specifically authorized the Secretary to establish ARPA, appoint a director, engage in R&D, and enter into contracts. Nothing was said about acquisition of facilities. The R&D work was to be done "for the military departments" in fields "not under the immediate jurisdiction of any military department."[40] The House passed the bill with this amendment. The Department protested to Senator Stennis, Chairman of the Senate Armed Services Subcommittee on Military Construction, and sent him Dechert's lengthy opinion in support of the Secretary's position.[41] The Senate Committee deleted Vinson's amendment in their version and said nothing about the issue of the Secretary's authority on the ground that it was a matter more germane to the forthcoming debate

* Dechert argued that in seeking money for ARPA to "acquire" facilities, DOD was thinking of funds to pay rent or the operating expenses of facilities that might be offered "free" by a university. He conceded that new construction would have to follow the pattern that applied to all military construction.

on overall DOD reorganization. Dechert worked with House Committee staff to find some acceptable language for a compromise at the House-Senate conference level. Actually Dechert was not really opposed to specific mention of ARPA in the bill, but he did not want to leave even a trace of a suggestion that it was necessary for the Secretary to have such authorization.[42] The House and Senate conferees resolved their differences by retaining some of Vinson's language and by agreeing to delete all specific reference to ARPA. Vinson was mollified and gave his approval to have McElroy set up the Agency internally. It had been touch and go. L. P. Gise recalls that when Wilfrid McNeil offered him the top administrative job in ARPA, the Vinson threat was so real that McNeil assured him another job would be found for him in OSD if ARPA could not be set up:[43]

> So the Agency was controversial even before it was formed. My deal with McNeil was that I would come over and handle the administrative end of the business, with the assurance that if the Agency went up in blue smoke that he would absorb me in his immediate office, and he had a job set up for that purpose. But it was that tenuous back in those days.

DOD was even worried about when to send up the formal letters to Vinson and Russell announcing ARPA, as required by the National Security Act, fearing that premature filing would generate opposition. Dechert's words on January 31 to two of McElroy's aides are illustrative:[44]

> We are, of course, temporarily waiting with the matter of giving notice of the proposed action to Messrs. Vinson and Russell in order to have as much guidance as possible on the right course of action which is to result. It is a matter of delicate balance to determine how long we dare wait before giving that notice.

The letters finally were sent on February 4, enclosing the draft DOD directive. It was formally promulgated, along with the announcement of Roy Johnson's appointment as Director of ARPA, on February 7, 1958.

The appropriation bill's progress was smoother, but not unaffected by the turmoil surrounding the authorization. The House Appropriations Committee supported the transfer of funds to ARPA in strong terms:[45]

> If it is to be successful the Advanced Research Projects Agency must not be allowed to become just another layer of paper work in the Office of the Secretary of Defense. It must be clothed with the authority and the control of funds necessary

> to conceive, coordinate, and implement research and development of essential programs of advanced science. If this is done, it could assist in large measure in bringing order and efficiency out of the chaos which has characterized efforts in this area in the past.

But in recognition of the Armed Services Committee's views, the Appropriations Committee wrote into the bill that the appropriations should be made to ARPA, "as authorized by law," i.e., contingent upon passage of an authorization act.[46]

When the bill reached the Senate, the Senate Appropriations Committee removed the "as authorized by law" clause on the advice of the Comptroller-General who said that without the clause the act of Congress appropriating the money would suffice both to recognize and approve the existence of ARPA. The Senate Committee also decided to delete all reference to ARPA, and simply appropriated the money to the Secretary, or his designee, to use as he saw fit. The Committee felt that too little study had been given to what the Agency would be and hence preferred neither to endorse nor to reject it.[47] The Senate passed the bill and the House concurred.

The authorization act (see Figure II-1) also addressed the issue of contracting authority and indicated that the Secretary or his designee could contract "through one or more of the military departments." OSD chose to ignore this language, feeling that the Secretary clearly had the authority to contract directly.

The defenders of Secretarial prerogative had scored an important victory. The Secretary had succeeded in establishing ARPA as an operating agency in OSD by internal directive and endowed it with the right to contract. On the other hand, ARPA was nowhere mentioned in legislation. Some of the Agency's leadership were subsequently to feel threatened by this lack of explicit legal sanction and to fret about the absence of authority to acquire facilities, fearful that without such sanction it would be disadvantaged in disputes with the Services and in a weak position to argue for adequate budgets. The ebullient Roy Johnson did not share those qualms.

ARPA is Created

The final version of the ARPA Directive (see Figure II-2) varied little from the November 29 draft. Words were added to underscore the fact that ARPA was only to work on individual projects or categories of work designated by the Secretary, and ever since his testimony to the House Appropriations Committee on January 8 he had been saying that it was not his intention ordinarily to have ARPA take over the R&D of weapons systems that fell clearly within Service missions. ARPA was

Figure II-1

AUTHORIZATION FOR ARPA

(Taken from Public Law 85-325 of February 12, 1958, "An Act to authorize the Secretary of the Air Force to establish and develop certain installations for the national security, and to confer authority on the Secretary of Defense, and for other purposes.")

Sec. 7. The Secretary of Defense or his designee is authorized to engage in such advanced projects essential to the Defense Department's responsibilities in the field of basic and applied research and development which pertain to weapons systems and military requirements as the Secretary of Defense may determine after consideration with the Joint Chiefs of Staff; and for a period of one year from the effective date of this Act, the Secretary of Defense or his designee is further authorized to engage in such advanced space projects as may be designated by the President.

Nothing in this provision of law shall preclude the Secretary of Defense from assigning to the military departments the duty of engaging in research and development of weapons systems necessary to fulfill the combatant functions assigned by law to such military departments.

The Secretary or his designee is authorized to perform assigned research and development projects: by contract with private business entities, educational or research institutions, or other agencies of the Government, through one or more of the military departments, or by utilizing employees and consultants of the Department of Defense.

The Secretary of Defense shall assign any weapons systems developed to such military department or departments for production and operational control as he may determine.

Figure II-2

TEXT OF DOD DIRECTIVE NUMBER 5105.15, FEBRUARY 7, 1958
(Establishing ARPA)

I. PURPOSE:

The purpose of this directive is to provide within the Department of Defense an agency for the direction and performance of certain advanced research and development projects.

II. RESPONSIBILITY AND AUTHORITY:

A. Establishment:

In accordance with the provisions of the National Security Act of 1947, as amended, and Reorganization Plan No. 6 of 1953, there is established in the Office of the Secretary of Defense the Department of Defense Advanced Research Projects Agency. The Agency will be under the direction of the Director of Advanced Research Projects.

B. Responsibility:

The Agency shall be responsible for the direction or performance of such advanced projects in the field of research and development as the Secretary of Defense shall, from time to time, designate by individual project or by category.

C. Authority

Subject to the direction and control of the Director:
1. The Agency is authorized to direct such research and development projects being performed within the Department of Defense as the Secretary of Defense may designate.
2. The Agency is authorized to arrange for the performance of research and development work by other agencies of Government, including the military departments, as may be necessary to accomplish its mission in relation to projects assigned.
3. The Agency is authorized to enter into contracts and agreements with individuals, private business entities, educational, research or scientific institutions including federal or state institutions.
4. The Agency is authorized to acquire or construct such research, development and test facilities and equipment as may be approved by the Secretary of Defense, in accordance with applicable statutes. However, existing facilities of the Department of Defense shall be utilized to the maximum extent practicable.

III. ORGANIZATION

A. The Director of Advanced Research Projects shall report to the Secretary of Defense.
B. The Department of Defense Advanced Research Projects Agency shall be provided such personnel and administrative support as may be approved by the Secretary of Defense.
C. Other officers and agencies of the Office of the Secretary of Defense within their respective areas of responsibility shall provide support to the Director of the Advanced Research Projects Agency as may be necessary for him to carry out his assigned functions.

IV. EFFECTIVE DATE

This directive is effective immediately.

authorized to enter into contracts, but the Secretary had said in the November 29 Randall memo that normally he expected ARPA to contract through the Services. The Directive also retained authorization to build or acquire R&D and test facilities, "subject to applicable statutes," but specifically stated that as a matter of policy existing DOD facilities would be used to the maximum extent practicable. No budget references were made. Loftis has said that McElroy was very keen on wanting to use Service funds for ARPA projects, in part to establish the principle that a Secretary could do so; but the Services made it clear in the early months of ARPA's existence that they would not reorder their priorities for funds that had been appropriated to them.[48] ARPA was soon totally funded by its own appropriation.

Thus ARPA started life by means of a DOD Directive issued by the Secretary on February 4, 1958; a supplemental Air Force appropriations bill enacted on February 11; and Congressional authorization in a section of a military construction bill enacted on February 12. The cart was a little bit before the horse, but ARPA was in business. Without Eisenhower's determined support, it is exceedingly doubtful that McElroy, or any Secretary, could have pulled it off.

McElroy's hopes for the new agency, as he personally explained them to Loftis and York, were relatively clear: (1) eliminating duplicate space R&D projects to prevent waste and controlling Service systems ambitions, and (2) reserving for himself the option of having a vehicle for conducting certain lines of research that the Services were not interested in doing, or did not want done.[49] His mood vis-a-vis the new ARPA was expansive. While offering Dr. York the job of ARPA Chief Scientist, for instance, he said that ARPA was going to take over all the military space work and "it just might, possibly, run the national space program." York also paraphrases the Secretary as saying, on many occasions, 'I want an agency that makes sure no important thing remains undone that does not fit somebody's mission.' ARPA's future appeared limitless.

ARPA: OPENING THE DOORS

ARPA's first two years were absolutely stormy, by any measure. The Agency probably hit its all-time "high" and "low" during this brief period. But somehow or other its basic course and characteristics for the next decade were essentially set in 1958-59. A group of major program assignments was acquired that carried ARPA through the 1960's and a management/administrative modus operandi was established. some of which remains in place today. Beset by enemies internally, subjected to critical pressures externally, and starting from scratch in a novel area of endeavor, ARPA was a tumultuous and exciting place to be. Consistent with the times, the Agency was presented with a controversial leader.

Roy W. Johnson

McElroy, as previously noted, arrived in office five days after Sputnik. In a sense it became "his" problem and his actions suggest that, as the new boy on the block in Defense, he was determined to make a major contribution to solving it. According to Killian, McElroy talked to him and to many others not only about the ARPA concept, but also about getting somebody to head it up.[50] The OSD Administrative Officer, J. Robert Loftis, who was responsible for taking the initial actions necessary to set up ARPA as a going concern, recalls that McElroy handled just about every aspect of the ARPA matter personally, up to the point that he brought Roy Johnson into the building and introduced him.[51] At that stage, Johnson took over and McElroy turned his attention elsewhere.*

Roy Johnson was McElroy's personal selection. The two men had known each other in business. Like McElroy, Johnson was a successful corporate executive and brand new to government. He proved to be a truly enigmatic character. Nobody knew Johnson when he arrived and nobody really claimed to know him when he left. He was an intensely private man, very religious, an amateur artist, and deeply committed to urban beautification and what later became known popularly as urban renewal. At age 52, he was an utterly confident, calm, strikingly handsome individual who looked every inch like a Fortune cover tycoon.

There was a certain mystique about his corporate career (which he did nothing to dispel). He was vaguely described as GE's ace troubleshooter or hatchet man, someone who was sent to hot spots, set up a small unit to deal with the problem, then phased it and himself completely out of existence once the problem was corrected. General C. M. Young, Jr. believes that such experience serves initially as a model for ARPA in Johnson's mind and that he had every intention of "finishing" the space development job and closing out ARPA in about two years time.[52] Philip Graham of the Washington Post wrote to Deputy Secretary Quarles, praising Johnson in glowing terms: "You are a genius to have grabbed him."[53] A protege of GE President Ralph Cordiner, it was also suggested that his days were numbered following the price-fixing scandals that severely tainted the Cordiner regime in the mid-1950's. Johnson, however, was never implicated. He remarked on one occasion that he decided to leave GE because his superiors had failed to face-up directly to the price-fixing problem.[54]

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* The general impression we draw from the group of our informants who were involved in the McElroy period is that he was an amiable, but relatively weak Secretary. Considered to be a "short-timer," apparently he was not taken too seriously in the Pentagon. In the ARPA memo, however, he emerges as a rather decisive, somewhat courageous decision-maker. This seems consistent with Charles Murphy's observation that the Secretary's performance in the immediate post-Sputnik crisis was considered "a tour de force that established McElroy as one of the star performers in the Eisenhower Cabinet." (Charles J. V. Murphy, "The Embattled Mr. McElroy," Fortune, April 1959, 149.)

Johnson was also a very wealthy man, leaving a $158,000 job to accept an $18,000 post at ARPA. For tax reasons, he took the ARPA job on condition that he would be permitted to be physically present in Connecticut for a minimal number of days. This meant he usually left Washington on Friday and returned Monday or Tuesday. He frequently used a private plane. The Secretary accorded him a high protocol ranking in the Department. Newcomers to the IDA and ARPA staff recall a cocktail party at which each was introduced by Roy Johnson to the Secretary and other notables. All this contributed to the mystique as well and there were many rumors that he had other special privileges, a government aircraft for personal use, a special personal relationship with the White House, and even an understanding that he reported directly to the President. Some thought that the only reason the directorship of ARPA was not a statutory position, subject to Presidential nomination and Senate confirmation, was in deference to Johnson's wish to avoid argument about divestiture of his investments.* This was not cited in a derogatory vein, but rather in the context of a certain awe towards such a powerful person. None of these assertions was correct, most notably the special White House connections. Indeed, as we shall see, the White House was to hold Johnson in rather low esteem, if not contempt, and this situation was to affect him and ARPA greatly.

When he took the job, Johnson said that he planned to stay 18 months to two years. He was said to be happiest when "building something," but lost interest when the job was done.[55] In the ARPA case, he left after 22 months. He had in fact built something, but this was not apparent to him at the time. He departed a somewhat disillusioned man.

Johnson had been a Vice President of GE since 1948 and had directed GE's electronics business for about six years. His reputation was built on management skill. He had no technical background, which was considered a great weakness in the White House. Killian and his group believed the times called for someone versed in science and technology and they were "much troubled" by his appointment.[56] Hence Johnson started off with one or two strikes against him in that quarter. McElroy, on the other hand, conceived the problem primarily in management terms. DOD had failed to organize and direct its resources properly; hence a hard-hitting business manager was needed. McElroy simply lacked confidence in the ability of a research man to take charge of organizing and managing a high priority program.[57] This was a view shared by Johnson, who often said with respect to scientists that "no one of them can ever run another one."[58] Killian confirms that "McElroy seemed to feel that Roy Johnson would bring management talents to this enterprise that are not normally found in DOD."[59]

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* By letter of February 11, 1958, the Secretary laid out the ground rules under which Johnson was to refrain from transacting business with GE, namely, by referral to the Deputy Secretary or Secretary. As a practical matter, the Deputy Director of ARPA handled any such business.

Johnson was a man of many contrasts and he defies simple pigeonholing; however, he had one overwhelming attribute: complete frankness, whatever the consequences. He simply said what he believed. Virtually all of his staff -- military, civil service and IDA -- worshipped him. One outside observer confirms that "he had a great sense of relation to and communication with his employees."[60] It shows through in their comments: "a fine gentleman," "the best boss I ever worked for," "a real leader," even "I adored the hell out of him." Johnson is remembered with genuine affection. One of the first IDA professionals to join the staff summed up the Johnson style this way:[61]

> He said three things to the staff that endeared him instantly: (1) we'll hang together or we'll hang separately, so there will be no barriers in exchange of information, (2) my door is always open, no problem is too trivial, and (3) I know nothing about science, but I do know management.

Despite being somewhat aloof as an individual, almost everyone recalls that he did practice an open door policy, encouraged and got a wide variety of opinions, relied heavily on his staff, consistently shared credit for successes with them, and continually backed his people. Many former ARPA staffers cite with obvious pride examples of decisions they made, with Johnson's support, despite considerable opposition. They marvelled at a photographic memory which enabled him to recite technical information, including all the numbers, without a note -- even though he might not be able to explain it. Criticism or "heat" never phased him, if he thought he was right. The whole tenor of the times was to do anything necessary to "get that edge" on the Soviets. He was prepared to do that and his staff, especially the IDA group filled with exciting ideas, took their cue accordingly.

By the same token, Johnson aggravated many outsiders. He became quite controversial because of his vigorous arguments with the Services. He took them on and was not the least bit intimidated by rooms full of Generals and Admirals. To some extent he surprised and annoyed them because "he didn't lay down and play dead. He felt that he had the power of the Secretary of Defense and he used it against his enemies."[62]

As noted, the outspoken Johnson also soon alienated the Killian group. Already suspect as a non-scientist, Johnson became a serious advocate of a strong military role in outer space. Killian, PSAC, the President, and to some extent Senator Lyndon Johnson, were of a different persuasion. This earned him the lasting enmity of an influential group that otherwise could have been a powerful ally. There was, says Killian, "no meeting of the minds between PSAC and Roy Johnson."[63] But McElroy was on record that Killian had little to do with defense matters* and Johnson -- if nothing, at least decisive -- promptly set out to insure U.S. superiority in space. This was, under the circumstances, more or less what one would expect the first Director of ARPA to consider as his first obligation.

McElroy had painted the new Agency in very brilliant colors. It was to seek out the advanced and unimagined weapons systems of the future, cut out waste, duplication and delay in space and ABM R&D, and accelerate the rate of progress by operating, rather than coordinating and paper-shuffling. The Secretary made his intentions quite clear in requesting a budget for the Agency:[64]

> It [ARPA] carries out its own functions. It is responsible only to the Secretary of Defense. I believe this is the first time there has been built up in the Office of the Secretary ... an actual operating agency.
>
> I would like this committee [House Appropriations] to think with me in terms of this being really a very promising part of the speeding up of all important actions in the defense area. We did not do this lightly at all. We believe that the projects of the future, which perhaps none of us except the best dreamers of the future can visualize will come to operational status much faster because of the directness of action which can be taken by this Agency.

Johnson believed that he had personally been given unlimited authority by the Secretary to produce results. He really thought that he was supposed to be the czar of the space program. He used to liken ARPA to a "fourth Service" in R&D, an analogy that continually gave the Services fits.[65] McElroy, however, had used it privately with Johnson and publicly before Congress in explaining the Agency's status.[66] "We think of that [ARPA] as simply being a fourth agency for doing research and engineering as the Army, Navy and Air Force are agencies for doing research and engineering." The entire rationale for having ARPA was to <u>do</u> something and Johnson was determined to carry out his mandate. As one of his associates has said, speaking of the early months.[67]

> We had all the power that it is possible to generate in government -- money, status, everything.

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* McElroy told the House Subcommittee on DOD Appropriations: "With respect to Dr. Killian ... I think there was a considerable amount of misunderstanding when the position was announced. I do not think the President ever had in mind that Dr. Killian was going to have any active connection with the Defense Department." (House Subcommittee on DOD Appropriations, <u>Supplemental Defense Appropriations for 1958</u>, Hearings, 85th Cong., 2nd Sess., January 8, 1958, 62.)

> We were living down World War II, the Cold War, the sinister technical competition, etc. Everyone felt that the scientific world had answers to all the problems, and as a matter of fact, that by obstructing them [the scientists] we had failed to go into space.

It is very hard to recreate on paper the heady atmosphere that prevailed in the United States generally and in ARPA specifically, but one small example may be helpful. Washington Junior High School in Toledo took up a "Moon Money" collection of $224.46 and sent it to the Treasury to be used in the U.S. space program. Treasury passed the check to ARPA, which had the money credited to its account. Roy Johnson wrote a letter of thanks and promised to try and enclose a copy of the school's letter in a space shot. Such was the outpouring of support for the nation's space effort.

ARPA Organization

Despite all the lofty talk, when Johnson arrived in the Pentagon on February 7 he was literally the first professional on board. There was no organization or staff. He started out with an office, a secretary, McElroy's hard-earned charter, and the temporary services of the Secretary's Administrative Officer, whom Admiral Clark recalls gave invaluable help to Johnson in getting ARPA under way. Even then it was not until April that Johnson was completely disengaged from GE.

The first order of business was staff. Johnson was instructed to select a military flag officer as his deputy. The Services each nominated a candidate and Johnson eventually selected Admiral John E. Clark. He was just completing a three year assignment as Director of Guided Missiles for the Chief of Naval Operations and wanted to go to sea. Clark, who was later to command U.S. naval forces at the Bay of Pigs, recalls accepting the ARPA assignment with considerable reluctance. But helping to create ARPA proved to be a rewarding task. "There were no charts and no soundings" and plenty of excitement.[68]

McElroy had also promised to bring in an outstanding scientist to complete the Agency's Leadership. For awhile Wernher von Braun appeared to have the job, but to get him it was necessary to take his 10-15 man package of associates and that was not acceptable.[69] Killian was keen on Dr. Herbert York, who had recently joined PSAC on a full time basis from his position as Director of the Livermore Radiation Labs and he was finally selected by McElroy. York has described the selection process:[70]

> [T]here is no doubt that Killian greatly influenced what was going on and that Killian was interested in having people over there who would be compatible with the whole scientific structure that

> was being created. And it's no accident, then, that I went from membership on the President's Scientific Advisory Committee to be Chief Scientist of ARPA. Now, that's not simply, though, Killian trying to get one of his people over there. I was not a long time associate of Killian.... I was somebody that Killian thought knew what was necessary, could contribute effectively, and was available -- I was all of those things.

York was also enthusiastic about space. One of the first things he did as Chief Scientist was hang a large picture of the moon on his wall next to an empty picture frame which, he felt, was "soon" to receive the first picture of the backside of the moon.

Clark and York joined ARPA in late March 1958. Clark began to assemble a small staff of technically-oriented military officers. Wilfrid McNeil, Assistant Secretary of Defense (Comptroller), recruited Lawrence P. Gise from the AEC to handle the Agency's financial management activity. William H. Godel, a senior member of the OSD Office of Special Operations, moved in to become Director of an Office of Foreign Developments. He was soon to take over responsibility for policy and planning activity in the Agency, later became a Deputy Director of ARPA, and emerged in the early 1960's as the protagonist for ARPA's most controversial major project assignment (AGILE).

ARPA was in desperate need of top-flight technical talent. There were few such people in the Civil Service and the best of them were already engaged on high priority projects. Outsiders were repelled by low salary levels. The "obvious" solution to men like Quarles and Killian was the Institute for Defense Analyses (IDA). They had been instrumental in setting up IDA in 1956 to infuse fresh scientific talent into the DOD Weapons System Evaluation Group (WSEG), which had foundered badly with Civil Service staffing. In a remarkably short time Johnson, and General James McCormick and Dr. A. V. Hill of IDA (respectively, President and Vice President of IDA and both former MIT colleagues of Killian) reached agreement on a concept under which IDA would establish a new ARPA Division to work exclusively on ARPA problems, with Dr. York serving in a dual capacity as its Director as well as the Chief Scientist of ARPA. York and the other scientists could be paid much higher salaries,* recruitment could proceed at once, and hopefully top-flight people would be willing to come in for 1-2 year tours of duty. Johnson and McCormick had settled this matter in principle by February 28 and McElroy formally proposed it to the IDA Board of Trustees on March 1:[71]

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* York served as ARPA Chief Scientist on a Without Compensation (WOC) basis.

> ... we submit for consideration ... a proposal that the Institute for Defense Analyses engage the services of Dr. Herbert York and back him up with a small group of the best scientific talent available for the purpose of taking on this work in support of ARPA. We would also propose that Dr. York serve as the Chief Scientist for ARPA.

The IDA Board responded favorably on March 15, Dr. York accepted IDA's offer effective Sunday, March 16, and the Loftis office commenced immediate negotiation of a contract.[72]

By May 1, 1958 eight IDA staff were at work and nine others were committed to join by June 15. Virtually all came from industry -- Lockheed, Rhom and Haas, Philco, GE, Union Carbide, Convair, Allied Research Associates, Douglas Aircraft, Aeroneutronics, Raytheon, RCA, RAND, and two from Kimball's Aerojet-General.[73] Three others had been in government positions. To say that this arrangement was unusual is an understatement. Johnson even wrote letters to major corporations requesting permission for IDA to talk to named individuals in those firms about joining the ARPA Division of IDA;[74] one new man who was asked to come to work "for the Secretary" did not know until he arrived in the Pentagon that he was in fact working for IDA.[75] Deputy Secretary Quarles insisted on personally approving every individual in the Division that was to be paid over $25,000 by IDA.[76] IDA and ARPA agreed on an informal ceiling of twenty-five individuals, most of them employed on a one-year basis under contracts arranged with their employers.

These men sat physically in ARPA and for many months were the ARPA technical staff. They often attended and/or chaired interdepartmental meetings as the <u>ARPA</u> representative. Gradually Civil Service and military technical counterparts were added to serve as responsible government officials on projects, but the IDA group dominated. Ostensibly York reported to the President of IDA, but that was "pure formalism." York in no sense considered that he was reporting to IDA; he worked for ARPA. Despite well-worded denials, IDA in effect became a "hiring hall" for ARPA.[77] Assembling such a relatively high-powered group on such short notice -- a matter of weeks -- testifies to the fact that the feelings of "threat" and urgency were deeply felt and widely shared around the country. The IDA arrangement began to draw criticism, on ground of propriety, almost from the day it began to function (discussed below), but it served its purpose well in the launching of ARPA.

Organizational Structure

ARPA's first organizational framework was very straight-forward. The Director's Office consisted simply of Johnson and the Chief Scientist (York), a special assistant for each of them, the Deputy Director (Admiral Clark) and three military officers reporting to him. ARPA attracted and/or the Services had the presence of mind to assign first rate officers to the

Agency in 1958-59. Some of them even got into trouble, e.g., Col. Dent Lay was personally bawled out by the Air Force Chief of Staff, Gen. Lemay, for failing to look out for the Air Force's interests.[78]

An office of Program Control and Administration (headed by L. P. Gise) consisting of seven civilian professionals, was set up to handle budgetary control and assignment of funds to Service agents for contracting (through what became formalized as the "ARPA Order" system), management reporting systems, and internal ARPA administration. A three-man Office of Foreign Developments (under W. H. Godel) initially contained the functions of review of foreign scientific developments, liaison with the intelligence community (a matter of some importance because of the reconnaissance satellite and tracking programs), security review, and liaison with the OSD public affairs office. This office soon handled anything with an international flavor, including efforts to fund research contracts in other countries, negotiating tracking station rights (e.g., in Australia and Spain), and lining up data exchanges with Canada and other NATO allies.

The largest and most important "division," however, was the Advanced Research Projects Division of IDA (ARPD/IDA) directed by Dr. York. It's functions were defined as follows:[79]

> Studies, reports and technical assistance in (a) space science and technology, (b) ballistic missile defense, and (c) other advanced research and development as may be assigned, to include the following:
>
> 1. Research, analysis and experimentation, including systems, equipment, components and facilities.
>
> 2. Systems engineering.
>
> 3. Analysis and evaluation of scientific and technical capabilities for research and development to achieve military and scientific objectives.
>
> 4. Interpretation and evaluation of the scientific data derived from tests and experiments.
>
> 5. Development of new programs.
>
> 6. Surveys and analyses of the effectiveness of various proposals and systems.
>
> 7. Evaluation of new equipment in the light of DOD needs.

8. Evaluation and analyses of military problems to predict the operational behavior of new material and equipment.

9. Development of proposed new military opportunities to meet changing requirements.

The IDA staff determined the substance of the first group of ARPA projects, planned those that should be considered for the future, and made the budget estimates for both. They were relied on to evaluate proposals and were the dominant voice in contractor selection. The IDA mechanism -- borrowing technical expertise from industry on 1-2 year assignment, with turnover to match ARPA program needs -- became a symbol of what ARPA came to hold as a self-image: urgency, excellence and flexibility.

This organizational structure was in place by May, 1958, and remained the basic framework for most of the year. As of mid-1958 IDA supplied a staff of approximately twenty-five scientists and engineers through its ARPA division, thus dwarfing the other elements of the organization.

The only major organizational change before December 1958, was the addition of an internal Contract Advisory Board in October to insure a more formal government review of research proposals, a problem created by the heavy reliance on IDA contract support. Undeniably, "there was a natural tension between the Pentagon people who in principle had the authority to make decisions and the IDA people with the technical know-how."[80] This issue persisted. The Board focussed primarily on structuring the nascent solid propellants program during its short life, being replaced by a more structured review mechanism called the ARPA Program Council in February 1959.

The first major restructuring of ARPA organization occurred in the period between December 1958 and February 1959. First, Johnson created a Technical Division (later Technical Operations Division, or TOD) explicitly to reduce IDA influence in policy planning, budget preparation, contract selection, and program management, i.e., those "duties ... of a type that should be performed by career service government employees."[81] TOD was planned to acquire a staff of about fifteen professionals and was simply added to the previously existing organizational structure. ARPD/IDA, however, was henceforth referred to with decreasing frequency as an integral part of the ARPA organization.

Almost immediately following the decision to create TOD, a further reorganization took place (January 1959).[82] It elevated L. P. Gise to the position of Assistant Director for Administration. He retained broad program administration functions; detailed budgetary, scheduling, ARPA Order preparation, and reporting system activities were put in a re-named Financial Management and Reports Division, headed by W. W. Bolton. The second facet of the reorganization was redesignation of W. H. Godel's office as the Policy and Planning Division. Its original functions of reviewing foreign research developments and maintaining liaison with intelligence sources were retained, but deemphasized. In addition to these activities, Policy and Planning was given broad responsibility for liaison with other federal agencies on policy matters, review of military requirements related to R&D, development of long-range program goals to guide fiscal and technical planning, and coordination and development of new work assignments in cooperation with the Technical Operations Division. The intent of the reorganization appears to have been to tighten ARPA managerial control over all aspects of the program. The reorganization was accompanied by a significant increase in ARPA staff, both Civil Service and military.

Creation of the Program Council capped this flurry of reorganization activity. The Council, to be chaired by the Deputy Director, included as members the Assistant Director (Administration) and his deputy, the Chief Scientist, the heads of the three ARPA divisions (other than ARPD), and a representative from OSD General Counsel. The function of the Council, like that of TOD, was to insure tighter governmental control over the heavily contractor-influenced ARPA program. Its specific tasks were to:[83]

1. Review for the Director and recommend to him a management position on IDA Technical Evaluations, and review to include program content and its relation to cost, policy and operational considerations.

2. Review and/or recommend arrangements by which ARPA projects will be carried out, to include contractor selection and negotiation where appropriate.

3. Review and make recommendation on other contract and procurement matters requiring ARPA decisions.

4. Review Development and Funding Plans for approved projects submitted pursuant to ARPA orders and make recommendations thereon.

5. Perform such other functions as may be assigned.

As dry as this recitation of tasks reads, Council members shared a sense of purpose. D. K. Hess says that the primary reason for setting it up was to cope with the incredible flow of competing ideas which "came in by the bushel."[84] Godel's recollection is similar: "There was this great mass of pent-up pressure and all ARPA had to do was the management job of selecting the best of the ideas. In essence, Roy Johnson [as Director] arbitrated among all the proposals."[85] The Council was intended to help make the choices, determine "why we did something," test the ideas proposed to insure that no "winner" lost out or that less worthwhile ideas got through, look at the possible future implications of what ARPA proposed to do, arrange coordination, consider management approaches, etc. Hess expanded on what he meant by "future implications:"[86]

> There was recognition that projects which we funded had some profound implications and that everybody who was alive had to appreciate what those implications meant for the future.

These remarks illustrate both the concerns of the time, namely, that no idea be ignored (no matter how hair-brained it might appear) and the feeling that ARPA staff had about the serious nature of their enterprise. Program Council procedures were to become highly formalized and were repeatedly amended and revised throughout its existence.

The Management Style

Roy Johnson is commonly associated with establishing a set of management principles for ARPA -- particularly the idea of a very small staff, contracting through the Services and using existing laboratories rather than ARPA facilities. The usual impression is that Johnson arrived on the scene with this model in hand and promptly acted on it. Actually, as disclosed in Chapter I, it was McElroy who laid out these basic ARPA attributes, as early as November 1957. The Services, for example, were reassured well before Johnson's appointment that ARPA would primarily use their contracting mechanisms and R&D facilities. While it is quite true that McElroy insisted on ARPA's right to contract directly and to acquire facilities, this seems to have been more of a "guard against all possible contingencies" measure and perhaps the result of a feeling that he could not afford to back down completely in the face of bitter Service opposition to the idea. The dominant thrust of the McElroy concept, confirmed by the process of developing the Agency's charter, was clearly away from building another bureaucratic empire. Undoubtedly Johnson was sympathetic with this approach, but it was also soon clear that he was stuck with it.

ARPA Laboratories. The most frequently cited and most misunderstood of the management issues pertains to ARPA laboratories. Johnson testified that when he arrived he was "offered" two laboratories, ABMA (and the von Braun team) and the Jet Propulsion Laboratory (JPL),* but turned them down during his first month on the job.[87] The ARPA files even include a draft DOD Directive for the transfer of ABMA, proposing that it be called the Defense Advanced Research Center, and a similar document for JPL.[88]

* Of all the Service "labs" these would be the most logical for ARPA to take over because there was growing realization in the Secretary's office that the only way to keep the Army from devoting resources to space work was to remove these prople and facilities, physically, from the Army. Strictly speaking, JPL was a contractor to the Army.

There apparently was lengthy discussion of acquiring the Naval Research Laboratories as well.[89] Johnson personally visited ABMA and JPL and other facilities. His top management adviser, L. P. Gise, argued strongly against taking them, or creating an ARPA procurement structure, because the administrative burden would ultimately drag ARPA down.[90] Loftis was also a strong proponent of farming work out to the Services and taking a 'use it rather than control it' approach to the laboratories issues. This, of course, was a faithful reflection of the notion sketched out in McElroy's November 6, 1957 preview of the Special Projects Agency. Gise had considerable experience with the management of AEC's network of field installations and Johnson placed a high value on his judgment. Johnson cited the "administrative burden" theory publicly whenever asked about the issue and the notion of a streamlined, hard-hitting ARPA shunning ownership of laboratories and utilizing the facilities of others became part of the established folklore in the Agency. Gise seemed to be most influential in rejecting ABMA and Johnson reacted so negatively to the Director of JPL, personally, that there was never any doubt that he would stay clear of it.

There is, however, another side to the story. Apparently when Johnson arrived he had no strong views on the laboratory question, and some of his advisors argued forcefully in favor of ARPA facilities. In his very first meeting with Johnson -- the job interview -- Clark urged Johnson to acquire field facilities. The Admiral felt very strongly that if ARPA were to succeed it would need such facilities and repeatedly pressed the point:[91]

> I told Roy that if we're going to accomplish what we have to do, we'll need a field installation like Redstone, and we'll be the policy-makers who protect them. Roy agreed a field agency was needed too.

The Clark notion was that ideally ARPA would be composed of "a small tight knit group in Washington and a large one in the field, with the former making policy decisions and protecting the best interests of the latter." W. H. Godel also favored acquisition of facilities on the theory that "if you own real estate, they can't kill you."[92] Godel gradually came to believe that the "farming out" theory of contracting was more of a burden than a blessing and clearly preferred to have ARPA own some assets of its own. He believes that Johnson was never fully convinced that having labs was a bad idea.

Admiral Clark states that Johnson actually did decide (some time after the rejection of ABMA in his first weeks) that it was necessary for ARPA to have facilities independent of the Services and discussed the issue with the Secretary directly:[93]

> Roy went to McElroy to talk about a number of things, including laboratories, and when he came back it was <u>dead</u> and never mentioned again.

Clark is very assertive about this and recalls that he interpreted it at the time as a significant event. It signalled to him that ARPA might be in difficulty: "McElroy must have stressed that ARPA was only a dam, or a finger in the dike, just until we got oriented [in space]."

The Executive Agent System. A second major feature of ARPA management style that was established prior to Johnson's arrival was reliance on Service contracting mechanisms and other administrative services. The first Secretary of Defense, James Forrestal, instituted the policy of using existing military department services and facilities to the maximum extent possible in lieu of duplicating them in his new Office of the Secretary. By the time ARPA was created, this was routine practice in OSD. A variety of arrangements had been worked out for budgeting, funding, accounting, audit, reporting, disbursing, personnel, payroll, travel, procurement, contracting and contract administration, etc. for OSD. As a rule, the Services were reimbursed for all costs except overhead. Most of this was "small potatoes" both as to the sums of money involved and the workload because OSD's staff offices had modest demands.

As OSD's first operating arm ARPA could use these arrangements, but some of its needs went well beyond them and the scope and magnitude of ARPA's activities were considerably different. The "executive agent" technique was known, but ARPA was probably the prime mover in developing its potential. Under this concept, ARPA selected a Service procurement agency to negotiate and administer contracts, and often to monitor technical performance on its behalf in accordance with instructions received from ARPA via an ARPA Order. The Service was not responsible for justifying either the project or its budget, it simply carried out the procurement action according to law. ARPA was authorized to deal directly with the Service action agency concerned; that is, it did not have to communicate via the regular channels from the Secretary of Defense to the Secretary of the military department, from him to the Chief of Staff, and on down. J. Robert Loftis was busy formalizing this system even before Roy Johnson's arrival. He "refereed" a number of meetings ("chairing," he said, "is too delicate a word") with the Services to lay out the ground rules for the levying of ARPA tasks.[94] He recalls spending a week at the Air Force Ballistic Missile Command negotiating and ultimately "dictating" an agreement with the Air Force. The Service attitude, of course, was 'give us the money and we'll do it.' They fought the notion that ARPA would give direction, monitor progress and evaluate what was done on its own terms.

Arranging direct access to the military field agencies was a major achievement:[95]

> We did establish, with difficulty, the principle of cutting out the higher echelons at Service headquarters, both for assignments of and reports about ARPA projects. It was anathema to the Services for a lower headquarters to deal directly with the Secretary of Defense's staff.

Normally, "channels" were rigorously followed. But McElroy's insistence on streamlined operation of the new agency make the somewhat revolutionary idea of having ARPA communicate directly with whomever was doing the work stick. This was a point frequently remarked upon in the aerospace trade press throughout 1958. While there were many kinks to be ironed out in making this system work, Gise recalls that most of the groundwork had been laid when he arrived.[96]

Other Aspects of Management. Turning to more general questions of management style, ARPA did not try deliberately to be a "pioneering" agency on the administrative side, despite all the talk about it being an innovative organization. Its main concern was finding an expeditious way to "get the job done," given the numerical constraints on ARPA's staff size. ARPA did not, for instance, attempt to promote new management techniques after the fashion of the Navy's Special Projects Office.[97] Indeed ARPA management staff were decidedly skeptical about the value of the latter's PERT system or any of the other management systems that passed in and out of vogue in the late 1950's and early 1960's. ARPA also paid no attention to the heated disputes of a philosophical nature that arose regarding the conduct of research and development and the "weapons acquisition process" in general, e.g., the in-house arsenal system vs. widespread use of private contractors; sequential evolution from research through development to test, production and deployment vs. the doctrine of "concurrency," which tended to telescope these functions under a single authority; and multiple sources of research (decentralization) vs. centralized control of R&D.[98]

Conceivably, ARPA could have been in the thick of these debates, but it was not. General Schriever did use "concurrency" among his many arguments for abolishing ARPA, i.e., the Service that is to use the weapons systems should be permitted to research and develop it and to carry on R&D, production, training, logistics and other functions related to it, concurrently; however, it would be difficult to claim that it played a crucial role in the minds of the Pentagon's leadership insofar as ARPA was concerned. Most ARPA staff considered it fallacious. Johnson described it after he left government as a "brute force approach" in which "lack of planning and mistakes are simply bulldozed under by more manpower and by more money."[99] Dr. G. W. Clever, a retired Air Force Colonel who worked for both Schriever and ARPA, also considered concurrency "a lot of bunk. All it meant was to keep spending a lot of money and rebuilding the thing until you get it."[100]

ARPA also could easily have been caught up in the centralization vs. decentralization debate that so troubled intellectuals such as Carl Kaysen, James Schlesinger, Charles Hitch, and Roland McKean.[101] Most of them were convinced that multiple approaches to R&D were superior, therefore any moves toward centralized control were dangerous for scientific progress. Creation of ARPA appeared to be just such a move; however, while ARPA was a "central" agency, it was to distinguish itself over the long term by encouraging support of alternative research approaches and ideas that operationally-oriented agencies tended to ignore or neglect. Thus ARPA was rarely accused of restricting R&D opportunities by exercising some form of dictatorial control.*

Although these few words hardly do justice to the endless hours spent in making the executive agent system work, ARPA's small financial management staff and their Service counterparts evolved a system by which ARPA could levy a procurement requirement on a specific Service agency; instruct it as to the objectives of the work, and the nature of the procurement approach to be used (sole source, limited bid, competitive bid); specify the role ARPA wished to play, if any, in the final selection decision; determine milestones and reporting requirements and the nature of the technical monitoring of the work that was to be done; and deal with the myriad details surrounding appropriations citations, the cycle of allocation/obligation/commitment/expenditure of funds, etc. It was an imperfect system, but it worked. There was a premium on "can do" attitudes by the personnel on both sides, in part because so many new problems kept arising and in part because at higher levels the roles and missions feuding between the Services and ARPA was extremely bitter.

There was a great deal of Service worry, initially, that ARPA would stack the deck vis-a-vis assignment of operating authority over new systems by means of its choice of Service agent for the R&D phases of the work. This proved to be less divisive an issue than originally thought because ARPA made some obvious assignments such as navigation to the Navy and reconnaissance and missile warning satellites to the Air Force; ARPA sometimes succeeded in getting multi-Service involvement in the same project; and ARPA exited the space field and important roles and missions decisions were made sooner than anticipated (within two years).

ARPA's Objectives

Johnson perceived that ARPA's job was to put up satellites. The space program became his principal interest. He paid little attention to ballistic missile defense or to other assignments received by the Agency. He did espouse, very early, a general rationale for what ARPA would do that was in many respects an excellent response to those critics, like Killian, who had been assailing military R&D for lack of inventiveness and undue rigidity:[102]

> It [ARPA] is in business to provide for the Department of Defense expedited and forward-looking research programs which in the past have been retarded by the necessity for a formal military requirement. The fact must be recognized and squarely faced that if an end requirement, be it military or any other, must be established before we embark on research, then by definition it is no longer research. It is our purpose to accelerate the national technological

* Some felt ARPA in fact encouraged too many crackpot ideas.

> status by sponsoring research without having to prove an ultimate specific application before we embark.
>
> In addition, ARPA will place emphasis on those research and development projects which are of immediate national interest and importance. ARPA is the manager and expediter of these very important projects.

The first ARPA program, which was long on rhetoric and short on specifics, fit well into this framework.

Although he knew nothing about space when he arrived, Johnson rapidly became a leading "space cadet."* Some of this undoubtedly was absorbed from the space enthusiasts in the IDA entourage, several of whom were clearly wild, or as York put it, "mad, in a friendly way."[103] Others have suggested that he absorbed it in part from enthusiasts in the Service like von Braun, Navy Captain Robert Truax, Schriever, and Medaris, with whom he regularly talked.[104] In any event, Johnson rapidly became the exponent of an aggressive military space program.

The core of his position is best expressed in a paper written for him by two members of York's IDA group in July 1958, which he particularly urged McElroy to read prior to space policy discussions with Killian and Eisenhower,[105] and which was frequently reflected in his later communications to McElroy and Quarles, speeches and policy positions. The paper assumes rapid acquisition of scientific knowledge about space and a matching expansion of technology leading, inevitably, to latent military applications. Man, as in the past, would underestimate the potential rate of growth of knowledge, technology and applications:[106]

> With the scientific-military aggressiveness the USSR has already demonstrated, it would be a fatal mistake to underestimate the military importance of space operations. As a nation, we are in deadly contest, for our survival with Russia. Thus the major purposes of space vehicles will be shaped by their military requirements.

Johnson genuinely came to believe this, as did many others, and the following extracts from the paper provide as succinct a summary of the frame of reference which infused Roy Johnson's ARPA as one could wish:[107]

---

* W. H. Godel recalls that Johnson actually tried to prevent ARPA from becoming identified as a group of unalloyed "space cadets" and constantly reminded the staff that 'we don't have printing presses for money.' (Discussion with W. H. Godel, June 18, 1975.)

As a matter of common sense, the United States cannot permit, from both a military and national standpoint, the USSR or any other nation to control space, operate exclusively in space or "take over" exclusively the moon or any other planet for exploitation beyond those specific areas our current limited visions [sic] can presently define. A strong military research and development program that will lead to manned and unmanned space orbiting weapons systems and space flight vehicles to permit military operations in space can be the key to future national survival. Important military operations in space will initially fall into the following four major areas:

1. Defensive Missions: where space systems are used in part or entirely to defend the U.S. and its holdings against vehicles such as ICBM's, IRBM's, satellite weapon carriers, etc.

2. Offensive Mission: where space systems are used in part or entirely to carry out the role of deterrence and strategic weapon delivery.

3. Information Missions: where space systems are used in part or entirely to carry out surveillance, communications, weather observations and space traffic control.

4. Military Space Bases and Logistics Mission: the utilization of space bases, man-made platforms, and the moon, to support, supply and help carry out the military missions in space as an important part of developing the required military capability to effectively operate in space.

Important military space vehicles and base support to carry out these four major missions will include the following:

(a) Global Surveillance vehicles
(b) Satellite space defense interceptor vehicles
(c) Strategic orbital weapon delivery vehicles
(d) "24-hour" stationary satellite vehicles
(e) "Man-made" space platforms used for emergency supply
(f) Moon base

> For purposes of this paper, our definition of Strategic Space Force is the capability to carry out the four military missions discussed with the types of space vehicles and bases mentioned....
>
> In summary, it is well to keep in mind that man's vision in totally new areas has been and will probably continue to be limited. The Russians are well down the space road and will continue to uncover many new and vital facts before us if we do not change our pace. We cannot continue to follow the usual "safe", conservative and critical line of approach which leads to a slow, "safe", and non-controversial course to progress. It has been demonstrated time and time again in the past that this conservatism and reluctance to engage in imaginative thought and advanced "state-of-the-art" change leads only to failure in the appreciation of useful applications for military-scientific principles and lessens or makes more expensive the pace of technical development when one tries to "catch-up". The best recent example of this involved both the ICBM's control and nuclear warhead. It was argued that the ICBM had little meaning because of guidance errors and heavy nuclear warhead weights. This subject was still under debate as recently as 1955. In a little less than three years the arguments and solutions involving both the ICBM guidance and control and its nuclear warhead weight have been resolved. We lost as a nation at least five years of ICBM research and development background because of this attitude. We cannot afford to follow this approach to future problems in the space age if we are to survive as a free nation.

And who was to deny unequivocally that "establishing a strategic space force may very well be the key to future national survival"?

Johnson periodically spoke of such things as orbiting nuclear weapons systems, death rays, and the like, although in fairness to him, more often than not he was using such examples in the context of doing sufficient research to guard against another Sputnik surprise in space, not as a flat prediction that they were actually at hand. Nonetheless Johnson was a missionary for space, a zealot, as reflected in these remarks in a speech to the New York State Bar Association on January 30, 1959:[103]

> We are, it seems to me, in the early years of another renaissance. In creating and encouraging this renaissance, we are integrating the talents of government, science, industry, education,

> religion and law into an endeavor so potentially magnificent it can only be upstaged by the goal it strives to attain -- a goal that involves not only a just and lasting peace here on earth, but, in a deeper sense, the moral extension of man's dominion in the universe.

Johnson tended to leave the substance of the space program to technical subordinates.

Establishment of "Natural" Limits on ARPA's Growth

Before discussing the content of the ARPA program, it is important to highlight two forces which were gathering momentum even as Roy Johnson was opening the Agency's doors and were shortly to alter its future completely. These were the National Aeronautics and Space Administration (NASA) and the Director of Defense Research and Engineering (DDR&E).

Five days before Johnson's appointment was announced, the President directed Killian to formulate a national space exploration program and to recommend the appropriate organization, military or civil, for it. The new ARPA Director was informed about this several days after his arrival.[109] By mid-month, the President was discussing the Killian assignment publicly. Indeed he was in a "race" with Lyndon Johnson because the Senator had already decided that 'I'm not going to let the generals get control of outer space.'[110] The Senate-House Armed Services Committee conferees had added a sentence to the ARPA authorization bill stating that the Secretary, or his designee, was authorized "to engage in such advanced space projects as may be designated by the President," for a period of one year. The reason for the limitation was to leave open the questions of the ultimate control of outer space and the organization to exercise it. Killian says that the White House was agreeable to this proviso and may actually have promoted it.[111] ARPA, said Senator Johnson, "was 'a temporary expediency' -- a means of keeping the momentum alive in our space and missile programs without foreclosing the future."[112] The Senator quickly jammed a resolution through the Senate establishing a bipartisan committee to determine space policy.

On March 24, 1958 the President formally approved ARPA's first set of "advanced space projects," but he conditioned the approval as follows:[113]

> I do so with the understanding that when and if a civilian space agency is created, these projects will be subject to review to determine which would be under the cognizance of the Department of Defense and which under the cognizance of the new agency.

At his news conference two days later, the President announced that he would shortly submit legislation "providing for civilian control and direction of governmental activities incident to civilian space programs." He also released PSAC's "Introduction to Outer Space" Report, which strongly endorsed a civilian and "peaceful uses of outer space" approach. On April 2 he forwarded a "Special Message on Space Science and Exploration" and the NASA bill to Congress and sent a memorandum to the Secretary of Defense and the Chairman of the National Advisory Committee for Aeronautics (NACA) directing them to determine which DOD space programs, including those he had just assigned the week before, should be transferred to the new agency.[114] Thus even before Roy Johnson had settled into his post as ARPA Director on a full time basis, part of his original inheritance was a matter of debate. Among other things, this complicated Johnson and York's staff recruitment problem because they could not flatly guaranty that ARPA would be the space agency.

In addition to his interest in a civilian space agency, President Eisenhower referred to a major study of defense organization in his State of the Union Message. It materialized on April 3, 1958 in the form of a major message and legislation for additional organizational reform. The Killian themes played a dominant role and the President's language was very strong: separate air, sea and land warfare was "gone forever;" modern science and technology had rendered classical military organization obsolete; the Secretary of Defense required clear and direct authority and funding flexibility, especially for new weapons development; and Service rivalries were going to be stopped cold:[115]

> Confronted by such urgent needs, we cannot allow differing service viewpoints to determine the character of our defenses -- either as to operational planning and control, or as to the development, production and use of newer weapons. To sanction administrative confusion and inter-service debate is, in these times, to court disaster. I cannot overemphasize my conviction that our country's security requirements must not be subordinated to outmoded or single-service concepts of war.

The President argued that the Secretary of Defense was hamstrung by excessive statutory restraints because of well-meant attempts to protect the traditions and prerogatives of the Services, but at a cost to the nation of "impaired civilian authority and [denying] ourselves a fully effective defense.... We must free ourselves of emotional attachments to service systems of an era that is no more." The conspicuous rivalries for weapons, funds and publicity were to be ended.

This sort of argument had been used in the course of deciding to establish ARPA. This time, however, Eisenhower went well beyond that concept, with strong urging from Killian, to create the position of Director of

Defense Research and Engineering. The President did say that the Secretary needed authority to centralize R&D projects "under his direct control in organizations that may be outside the military departments," an apparent confirmation of ARPA, although most R&D work would continue inside the Services.[116] To give the Secretary the means to control DOD R&D, the DDR&E was recommended, ranking at a level below the Service Secretaries but higher than Assistant Secretaries of Defense and the Director of ARPA. His duties were to include supervision of all research and engineering activities in DOD, "including those of the Advanced Research Projects Agency." The President anticipated plenty of political heat on this recommendation, but was determined to get his way. The Defense Reorganization proposals were vintage Eisenhower; indeed, he went to the unusual extreme of personally drafting the reorganization bill, almost word for word.[117]

ARPA opened its doors, then, with an urgent top priority mission but also in the midst of continuing debate over the creation of two new organizations that conceivably could threaten or supercede it. By the late summer of 1958 both NASA and DDR&E had been enacted into law. NASA, based on the NACA organization, had to be dealt with immediately. The search for a man to serve as the DDR&E took about six months, so the full impact of that event was deferred until early 1959.

CHAPTER II: FOOTNOTES

1. C. M. Green and M. Lomask, Vanguard: A History (Washington: Smithsonian, 1971) 200-202.

2. Memorandum for the Secretary of Defense from W. M. Holaday, Assistant for Guided Missiles, "Organization for Missile Project Management," undated (early November, 1957).

3. Letter to William L. Dawson, Chairman, House Committee on Government Operations from Frank D. Newbury, May 16, 1958, published in House Committee on Government Operations, Subcommittee, Research and Development, Hearings, 85th Cong., 2nd Sess., July 14-18, Part 2, 478.

4. Claude Witze, "Scientists Clash with Newbury on Policy," Aviation Week, April 15, 1957, 26-27.

5. Aviation Week, February 3, 1958, 37.

6. Discussion with Charles Thomas, May 21, 1975.

7. Discussion with L. P. Gise, April 7, 1975.

8. Charles J. V. Murphy, "The White House Since Sputnik," Fortune, January 1958, 101.

9. Discussion with Dr. James R. Killian, Jr., May 8, 1975.

10. Memorandum for the Secretary of Defense from Robert Dechert, "Central Control of Anti-Missile Weapons and Satellites," November 6, 1957.

11. House Subcommittee on DOD Appropriations, The Ballistic Missile Program, Hearings, 85th Cong., 1st Sess., November 20-21, 1957, 7.

12.1 Discussion with William H. Godel, June 18, 1975.

13. Discussion with J. Robert Loftis, July 18, 1975. Many people, like McNeil, believed in the virtues of competition in R&D and a substantial literature on this issue was built up by intellectuals such as Charles Hitch, James Schlesinger and Carl Kaysen.

14. Sherman Adams, Firsthand Report (New York: Harpers, 1961) 405.

15. Aviation Week, May 20, 1957, 25 and November 25, 1975, 26-27.

16. Discussion with J. R. Loftis, July 18, 1975.

17. Discussion with Dr. J. R. Killian, Jr., May 8, 1975.

18. Dwight D. Eisenhower, "Our Future Security," Radio and Television Address, November 13, 1957.

19. Unless otherwise noted, the information in this and immediately following paragraphs is taken from four Memoranda for the Secretary of Defense, each dated November 23, 1957, from: W. B. Franke, Acting Secretary of the Navy, "Comments on Establishment of Special Projects Agency in the Department of Defense;" N. F. Twining, Chairman, JCS, "Department of Defense Special Projects Agency;" Wilbur M. Brucker, Secretary of the Army, "Proposed Department of Defense Directive;" and James H. Douglas, Secretary of the Air Force, "Draft of Letter and Directive Concerning Proposed Special Projects Agency."

20. House Subcommittee on DOD Appropriations, op. cit., 23 and 63.

21. Aviation Week, November 25, 1957, 26.

22. Memorandum for General Randall from Paul D. Foote, "Department of Defense Special Projects Agency," November 23, 1957.

23. Memorandum for the Secretaries of Army, Navy and Air Force and the Chairman, JCS from Brig. Gen. C. A. Randall, Military Assistant to the Secretary, November 29, 1957.

24. Memorandum for the Secretary of Defense from Thomas S. Gates, Secretary of the Navy, "Comment on Proposed Secretary of Defense Directive entitled 'Department of Defense Directive Advanced Research Projects Agency,'" December 21, 1957.

25. Memorandum for the Secretary of Defense from N. F. Twining, Chairman, JCS, December 6, 1957.

26. Memorandum for the Secretary of Defense from James H. Douglas, "Draft Directive Establishing an Advanced Research Projects Agency," December 14, 1957.

27. Aviation Week, December 15, 1957, 26

28. Aviation Week, December 23, 1957, 18-19.

29. Ibid.

30. Ibid.

31. Discussion with Admiral John E. Clark, July 8, 1975.

32. House Doc. No. 298, 85th Congress, 2nd Session.

33. Rockefeller Brothers Fund, "Report II - International Security: The Military Aspect," Prospect for America (Garden City: Doubleday, 1961) 124-25. Report II was first published January 6, 1958 and released to the press on January 9, 1958.

34. New York Times, January 11, 1958.

35. House Armed Services Committee, Investigation of National Defense Missiles, Hearings, 86th Cong., 1st Sess., January 13, 1958, 4060.

36. Ibid.

37. Ibid., see especially pp. 3981, 3991 and 4073-78.

38. Ibid., 4076.

39. Cited in Memorandum for the Secretary of Defense from Robert Dechert, "Legal Authority of the Secretary of Defense to Establish the Department of Defense Advanced Research Projects Agency," January 6, 1958.

40. House Committee on Government Operations, Organization and Management of the Missile Programs, House Report No. 1121, September 2, 1959, 134.

41. Letter to Senator John Stennis from Neil McElroy, January 20, 1958.

42. House Armed Services Committee, op. cit., 4078.

43. Discussion with L. P. Gise, April 7, 1975.

44. Memorandum for Mr. Oliver Gale and B. G. Carey Randall from Robert Dechert, January 31, 1958.

45. Cited in House Committee on Government Operations, Organization and Management of the Missile Programs, 135-56.

46. House Armed Services Committee, Reorganization of the DOD, Hearings, 85th Cong., 2nd Sess., May 8, 1958, 6685.

47. House Committee on Government Operations, Organization and Management of the Missile Programs, 136.

48. Discussion with J. R. Loftis, July 18, 1975.

49. Ibid., and discussion with Dr. Herbert F. York, April 4, 1975.

50. Discussion with Dr. J. R. Killian, Jr., May 8, 1975.

51. Discussion with J. R. Loftis, July 18, 1975.

52. Discussion with Brigadier General C. M. Young, Jr., USA (Ret.), October 25, 1975. Then - Lt. Col. Young was one of the first military officers assigned to the ARPA staff. Johnson did not discuss this matter directly with Young, nor with anyone else, to his knowledge.

53. Letter to Donald Quarles from Philip Graham, February 7, 1958.

54. Discussion with Wilbur W. Bolton, Jr., May 13, 1975.

55. New York Times, February 8, 1958.

56. Discussion with Dr. J. R. Killian, Jr., May 8, 1975 and Dr. H. F. York, April 4, 1975.

57. Discussion with J. R. Loftis, July 18, 1975.

58. Discussion with W. H. Godel, June 18, 1975.

59. Discussion with Dr. J. R. Killian, Jr., May 8, 1975.

60. Discussion with J. R. Loftis, July 18, 1975.

61. Discussion with Dr. Richard Holbrook, July 10, 1975.

62. Discussion with J. R. Loftis, July 18, 1975. Col. Dent Lay, USAF (Ret.) and others use virtually the same language in characterizing Johnson.

63. Discussion with Dr. J. R. Killian, Jr., July 18, 1975.

64. House Subcommittee on DOD Appropriations, Supplemental Defense Appropriations for 1958, Hearings, 85th Cong., 2nd Sess., January 8, 1958, 39 and 50.

65. Discussion with Dr. Charles Townes, July 10, 1975.

66. House Subcommittee on DOD Appropriations, Hearings, Department of Defense Appropriations for 1959, 85th Cong., 2nd Sess., April 29, 1958, 395.

67. Discussion with W. H. Godel, June 18, 1975.

68. Discussion with Admiral J. E. Clark, July 8, 1975.

69. Discussion with J. R. Loftus, July 18, 1975.

70. Discussion with Dr. H. F. York, April 4, 1975.

71. Memorandum for Mr. McElroy from Roy W. Johnson, February 28, 1958 and letter to Dr. T. Keith Glennan, Chairman, Board of Trustees, IDA from Secretary McElroy, March 1, 1958.

72. Letters from A. G. Hill to Roy W. Johnson, March 19, 1958 and from Johnson to Hill, March 31, 1958.

73. Memorandum for the Secretary of Defense from Roy W. Johnson, May 1, 1958.

74. For instance, a letter from Roy Johnson to Mark Cresap, President, Westinghouse Electric Corp., April 29, 1958.

75. Discussion with Dr. R. Holbrook, July 10, 1975.

76. Discussion with L. P. Gise, April 7, 1975.

77. Discussions with Dr. H. F. York, April 4, 1975 and L. P. Gise, April 7, 1975.

78. Discussion with Col. D. Lay, June 17, 1975.

79. Organization Chart, "Department of Defense Advanced Research Projects Agency," May 1958.

80. Discussion with Dr. Charles Townes, July 10, 1975.

81. Memorandum for the Secretary and Deputy Secretary of Defense from R. W. Johnson, "ARPA Organization," December 5, 1958.

82. Memorandum for the Staff from R. W. Johnson, "Reorganization," January 29, 1959.

83. Memorandum for the Staff from R. W. Johnson, "ARPA Bulletin No. 9, Amended - Establishment of ARPA Program Council," February 16, 1959.

84. Discussion with Donald K. Hess, March 22, 1974.

85. Discussion with W. H. Godel, June 18, 1975.

86. Discussion with Donald K. Hess, March 22, 1974.

87. House Subcommittee on DOD Appropriations, Hearings, *Department of Defense Appropriations for 1959*, 85th Cong., 2nd Sess., April 23, 1958, 291.

88. The drafts are undated. There is an indication that the ABMA paper may have been prepared by George H. Clement of RAND during the period just before ARPA's creation while he was a member of the Special Capabilities Advisory Group in DOD, the technical panel chaired by Dr. Homer J. Stewart that advised Quarles on the Vanguard program.

89. Discussion with W. H. Godel, June 18, 1975.

90. Discussions with L. P. Gise, April 7, 1975; W. H. Godel, June 18, 1975; Adm. J. E. Clark, July 8, 1975; and J. R. Loftis, July 18, 1975.

91. Discussion with Adm. J. E. Clark, July 8, 1975.

92. Discussion with W. H. Godel, June 18, 1975.

93. Discussion with Adm. J. E. Clark, July 8, 1975.

94. Discussion with J. R. Loftis, July 18, 1975.

95. *Ibid.*

96. Discussion with L. P. Gise, April 7, 1975.

97. For an analysis of the Special Projects Office see Harvey M. Sapolsky, *The Polaris System Development* (Cambridge: Harvard, 1972).

98. The earliest serious study of the weapons acquisition process is Merton J. Peck and Frederic M. Scherer, *The Weapons Acquisition Process: An Economic Analysis* (Boston: Harvard Business School, 1962).

99. House Committee on Science and Astronautics, *To Amend the National Aeronautics and Space Act of 1958*, Hearings, 86th Cong., 2nd Sess., March 30, 1960, 402.

100. Discussion with Dr. G. W. Cleven, June 5, 1975.

101. See, for example, Carl Kaysen, "Improving the Efficiency of Military Research and Development" in Carl J. Friedrich and Seymour E. Harris (eds.) Public Policy, Vol. XII (Cambridge: GSPA, 1963), 219-273; James R. Schlesinger, Organizational Structures and Planning," in Roland N. McKean (ed.) Issues in Defense Economics (N.Y.: NEBER, 1967), 196-97; Sapolsky, op. cit., 201-04; and Michael H. Armacost, The Politics of Weapons Innovations: The Thor-Jupiter Controversy (N.Y.: Columbia, 1969).

102. House Subcommittee on DOD Appropriations, Department of Defense Appropriations for 1959, Hearings, 85th Cong., 2nd Sess., April 23, 1958, 291.

103. Discussion with Dr. H. York, April 4, 1975. Dr. R. Holbrook makes a similar assessment: "We had some strange ones ... some absolute nuts [but] nobody who didn't have something going for him" (Discussion, July 11, 1975).

104. Discussion with W. W. Bolton, Jr., May 13, 1975.

105. Discussed in a Memorandum for Mr. McElroy (which he noted receiving) from C. A. Randall, July 25, 1958. Brig. Gen. C. A. Randall, USMC, was the Secretary's Special Assistant.

106. Richard S. Cesaro and Robertson Younquist, "Strategic Space Force, Key to National Survival," July 22, 1958 (Technical Staff, ARPD/IDA), 1.

107. Ibid., 1-2 and 13-15.

108. Cited in U. S. News and World Report, February 9, 1959, 102.

109. Memorandum for Mr. Johnson, Director, ARPA from Donald A. Quarles, February 8, 1958.

110. Cited in Newsweek, February 17, 1958, 26.

111. Discussion with Dr. J. R. Killian, Jr., May 8, 1975.

112. Newsweek, February 17, 1958, 26. Cf. House Armed Services Committee, Organization and Management of Missile Programs, 135.

113. Memorandum for the Secretary of Defense from Dwight D. Eisenhower, March 24, 1958.

114. Dwight D. Eisenhower, "Special Message to the Congress on Reorganization of the Defense Establishment," April 3, 1958.

115. Ibid.

116. Ibid.

117. Adams, op. cit., 406 and 408.

NOTE: In Chapters II, III and IV numerous ARPA memoranda and OSD memoranda concerning ARPA are cited. These sources were drawn from retired ARPA files of the period (1958-1960) and were either unclassified in the original or have been declassified by ARPA, Technical Information Office.

Chapter III

THE "SPACE" AGENCY: 1958-1959

ARPA received five important program assignments in the Johnson era: outer space, ballistic missile defense, solid propellent chemistry, materials science, and nuclear test detection. Each had a direct White House connection and the space, BMD and nuclear test detection projects were later to be called "Presidential issues." With the exception of a critical addition to the BMD program in 1961; Project AGILE, which more or less insinuated itself into the White House the same year; and a couple of highly specialized tasks (e.g., improving the safety of the Presidential automobile following the Kennedy assassination), ARPA was never again to receive or engage in other White House or Presidential issue assignments.

The outer space and ballistic missile defense assignments had been approved by the President about two weeks before ARPA was established. At the National Security Council meeting on January 22, 1958 he accepted a series of recommendations from McElroy and Killian according highest national priority to certain projects from research and development through operational readiness. Among them was ballistic missile defense, the IGY scientific satellites (Vanguard and Explorer), and such satellite programs other than Vanguard and Explorer that the Secretary of Defense determined to have "key political, scientific, psychological or military impacts."[1] The solid propellant chemistry assignment was virtually on ARPA's doorstep, generated by PSAC, when the Agency opened its doors. There was already PSAC momentum at that time behind what proved to be the materials sciences task. Nuclear test detection became a dominant White House concern later in 1958-1959 and the R&D aspects of that problem were brought to ARPA toward the end of Johnson's tenure.

THE SPACE PROGRAM

Assignments were the easy part; establishing a program was something else. Just as Johnson had no fixed blueprint for organization, he had none for a program. In fact, "he didn't have the faintest idea how to start a program."[2] But he did have a flair for motivating people. Accordingly he turned to his staff and said, in effect, "You people are the experts -- you tell me and I'll do it."[3] It was a tall order because, as Admiral Clark observed, "we were all barely educated from a technical point of view."[4] They worked endless hours.

The ARPA Budget

Johnson, Clark and York had barely been on the job for a month, full time, when they were required to present a program and a budget for FY 1959. A rather remarkable "program" was produced and the magic number of $500 million was literally pulled out of the air for a start-up budget. Johnson and York performed brilliantly on the Hill. Newspapers and even the hostile Aviation Week applauded the Agency and reported that Congress and the Services were impressed:[5]

> Johnson's testimony and that of the ARPA leaders drew considerable praise from the House Defense Appropriations Subcommittee members. They voiced the conviction that as presently conceived, ARPA would maintain and make use of the broad base of independent investigations taking place in U.S. laboratories and would expedite the incorporation of new ideas into weapon systems policy.

Figure III-1 shows the Agency's first formal program categorization.

ARPA's first few months of operation coincided with the last months of FY 1958. The Agency drew $10 million via supplemental appropriation and about $40 million from the Secretary's Emergency Fund for that period. The FY 1959 request of $520 million rolled through the Congress unscathed. Then the Agency's serious forward planning and budgeting began, pursued mostly by military officers assigned to Godel's office. The first comprehensive budget total, based almost exclusively on estimates elicited from the IDA technical staff on the basis of the minimum amounts they felt they could get by with was $2.5 billion.[6] Johnson considered that figure about twice as high as he was prepared to go forward with, so Cols. Sturges and Young in Godel's office produced a $1.5 billion version. Analysis of the various estimates showed that each technical project officer had built in a full complement of back-up launch vehicles as a hedge against program disruption. Deletion of excess back-up boosters accounted for most of the $1 billion reduction. Young believes that Johnson held some tentative discussions of the $1.5 billion figure at his level, e.g., with York and perhaps with the Secretary, and then decided that $1 billion was the most that ARPA could hope to get. Another round of analysis produced a $1.003 billion program figure. One large ARPA Plan spread sheet printed in July 1959 shows a $646.1 million FY 1960 estimate, $1.069 billion in FY 1961 and a gradual rise to $1.859 billion in FY 1966.[7] A second version moved from $587.6 million in FY 1960, to $712 million in FY 1961 and gradually on up to $1.071 billion in FY 1964 (where it stopped).[8] The Agency's actual FY 1960 proposal to the Secretary was $738.2. ARPA never came close to reaching any of these figures.

Figure III-1

Advanced Research Projects Agency,
Fiscal Year 1959 Program
(In Millions)

1.	Missile Defense Against ICBM	$157.4
2.	Military Reconnaissance Satellites	152.0
3.	Military Developments For and Applications of Space Technology	138.2
	3.1 Man in Space	
	3.2 Special Engines	
	3.3 Special Components for Space Systems	
	3.4 Project ARGUS	
	3.5 Satellite Tracking and Monitoring Systems	
	3.6 Satellite Communications Relay, Meteorological Reporting, Navigational Aid Systems	
	3.7 Bomb-Powered Rocket	
	3.8 Solid Propellents	
4.	Other Advanced Research [the Scientific Satellite Programs]	72.0
	4.1 ABMA/JPL Program	
	4.2 AFBMD Program	
	4.3 NOTS Program	
	4.4 Follow-On Program	
5.	Executive Direction	.4
		$520.0

Source: House Subcommittee on DOD Appropriations, Department of Defense Appropriations for 1959, Hearings.

Johnson did not make a public issue of funds for ARPA,* as he did with his belief in a distinct military role in space, but he definitely believed that a space program (whoever conducted it) could not be achieved "on the cheap." He told Lyndon Johnson's Special Committee in May 1958 that it was his personal opinion a comprehensive space program would have to grow to the level of $1-2 billion per year and perhaps more.[9] York also assumed that a sensible ten-year program of space science and exploration would have to average roughly $1 billion annually.[10] Johnson formally suggested the necessity of a one billion dollar ARPA budget to the Secretary in the summer of 1959:[11]

> I believe the project effort reflected in the 1961 B request ($712 million) represents an absolute minimum. To have a program reflecting the policy statements of the OCB and the NSC pertaining to U.S. space effort, as well as to meet the military service operational date requirements, would require a budget more nearly of the magnitude of one billion dollars for 1961.

If DOD were to seek the lunar capabilities supported by the Services, it would be necessary to build up to an additional $1 billion per year by 1964.[12] By the time Johnson testified as a private citizen in the spring of 1960 he had become convinced that achieving a maneuverable, recoverable space vehicle capability and a fully effective defense against missiles would consume the entire military budget.

These figures were troublesome in DOD and anathema in the White House and OMB. For instance, Killian and BOB tried to lay a ceiling of $300 million on the total FY 1959 space budget for both ARPA and NASA, exclusive of reconnaissance satellite funding. Johnson opposed any ceiling but agreed to have York and Hugh Dryden of NASA try to develop a list of priority projects totalling $300 million. He reported the results to Quarles as follows:[13]

> Yesterday afternoon Dr. York and Dr. Dryden, after two sessions, advised me that the minimum space budget they could recommend was $400 million and

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* At the very end of his tenure he did "go public" with a demand for more funds for the Saturn IB booster project, but that was independent of whether ARPA or some other agency managed it. On one occasion, perhaps this one, Johnson was reprimanded by the President for letting it be known on the Hill that he wished there was more money for military space programs. Of the White House reprimand, said L. P. Gise, "I know he got a big kick out of it. It didn't bother him, obviously." (Discussion with Gise, April 7, 1975.)

> that it was not practical to attempt a priority listing. They further stated that this budget would not, in their opinion, put us on the road to overtaking the Soviets in the space race. This position was presented last night by them at a special meeting of Dr. Killian's Space Committee.

He may also have taken some comfort in an OMB calculation of a total proposed FY 1960 budget for ARPA, NASA and others equal to $1.061 billion, which was discussed by Killian, Quarles, Glennan, York and others on November 13, 1958.[14] He probably did not like their decision to make a tentative cut of almost $200 million, most of which was to be absorbed by ARPA, and he certainly did not like the final result of that process. ARPA's $738.2 FY 1960 request ($543.5 million for space) was trimmed to $480 million ($330 million for space). The Secretary appealed to the President for that sum and came away with $455 million ($307 million for space). Johnson, knowing that his programs would of necessity grow and induce new budget demands, could readily see the inconsistency of attempting to manage and expand them in the face of a declining future budget. His FY 1961 claim for over $700 million also failed miserably. Admiral Clark and others say that Johnson was deeply disturbed by these events. They seemed completely at odds with the charter he had been given and raised doubts in his mind regarding the Agency's future.

Figure III-2 provides a budget summary for the ARPA programs during Roy Johnson's tenure.

ARPA Space Planning

ARPA budgets were, of course, tied to programs and plans for future programs. The ARPA planning documents of the period are somewhat striking. In a matter of weeks virtually every plausible outer space program idea had been identified and as time wore on these were sorted into priorities. It appears that it was more difficult to decide what should be civilian or military or civil-military than to determine technically what could be done. Virtually all of what emerged in the NASA program of the 1960's was on paper in ARPA by the summer and fall of 1958, as well as a decided interest in space platforms and recoverable space vehicles. The ARPA vision of the future was based on the maneuverable, recoverable vehicle concept, which presupposed development of a super-thrust vehicle and teaching man how to function in space.

ARPA planning also involved attempts to bring the Services into the process. Special committees and panels were set up to think about military uses and "requirements" on a multi-Service basis. Individual staff contacts throughout the military departments were constantly pursued. In addition to obvious contacts with Service R&D units it was necessary to try and educate the operationally oriented elements who controlled the Services to the substantive promise and limits of space

Figure III-2

Program Budget History During The Johnson Period
($ millions)

	FY 1958	FY 1959	FY 1960
Appropriations Request	10[1]	520[3]	455
Actual Budget	83[2]	520	455
Commitments to Agents	43	466	276[4]
Requests By Program:[5]			
Space/Satellites	1.6	290	307[8]
Ballistic Missile Defense	-	157[7]	128
Other Advanced Research[6]	8.2	72	-
Propellants	-	-	18[9]
Other	-	-	-[10]
Administration	.2	.4	2

1 Transfer from "Contingencies, Department of Defense," February, 1958.

2 Amount designated by ARPA as "available for commitment" in the February-June, 1958 period through various transfer and adjustments.

3 Included a negative "unobligated balance" of $40 million to cover pre-FY 1959 activities and adjust accounts. FY 1959 appropriation was later adjusted to $400 million, taking into account transfers to NASA and Services.

4 Low commitment figure reflects transfers of military space programs to Services in FY 1960.

5 FY 1958 figures do not reflect funds available through several transfers and adjustments.

6 Primarily "non-military space technology."

7 Includes $57 million for NIKE-ZEUS, transferred to Army.

8 Approximately $200 million transferred to Services.

9 Previously funded through space/satellite category.

10 Approximately $17 million transferred to Materials and $8 million to VELA in FY 1960 from other accounts.

__Note:__ On this and subsequent budget tables, funding levels for specific programs are indicated by requests rather than "actuals." ARPA's program offices are not necessarily binding budget categories, hence there is considerable room for adjustment, reprogramming and allocation of budget cuts following final appropriations to the Agency as a whole (though Congress occasionally specifies cuts in, or elimination of, a particular program). Estimates of what was "actually" spent in a given year in a given office are frequently adjusted in subsequent years, a problem complicated by disposition of unobligated funds. Program requests generally approximate the actual level of effort expended. Where there is an important exception, explanation is provided in the textual description of the program.

technology, and the costs involved. Full-scale briefings on the major satellite programs were presented to the JCS, sometimes on a twice weekly basis. Senior IDA technical staff usually prepared and delivered these presentations. ARPA also worked hard to overcome Service suspicions borne of their resentment of ARPA's creation and McElroy's characterization of it as a "fourth Service" for R&D. Jealous of each other and decidedly uncertain about ARPA, the Services presented a formidable challenge. It was exhausting endeavor, in part because Service roles and mission animosities were so intense throughout the period.

Despite its image as an unrestrainted promotional agent for outer space, ARPA's role vis-a-vis the Services were frequently that of the nay-sayer. The Services produced "requirements" for a comprehensive range of earth-orbiting systems, lunar systems and interplanetary or "trans-lunar" systems.[15] ARPA refused to consider the interplanetary category. It professed willingness to consider some conceptual study of the lunar regime (but did not), and rejected initiation of lunar projects before the 1967-70 period. The emphasis was to be placed on earth-orbiting systems. A comprehensive list of the Service requirements and relevant ARPA projects (actual and planned) is shown in Figure III-3. While ARPA sought to justify the space program and space budgets on alleged military requirements and operational target dates whenever possible, it spent more time trying to control Service desires than in fomenting them. The hard message ARPA tried to drive home was, in essence: (1) space-based systems are in most cases an alternative to achieving a purpose that can be satisfied in other ways, (2) the operational costs of space-based systems will exceed their research and development budgets by perhaps a factor of ten, and (3) ARPA will fund and test the feasibility of space systems concepts, but Service budgets will have to fund complete development, production and deployment, i.e., space systems will compete with conventional systems, and they will not necessarily bring additional funds. ARPA was acutely aware that so long as it funded the work, one or more of the Services was likely to manufacture a "requirement" to keep it alive. Rapid introduction of a budding space system into a Service budget, without the money, was a revealing litmus test of the validity of any "requirement."

The only official or published long-range ARPA plan was produced in the summer of 1959. The first version of the plan, prepared for submission by the Secretary to the JCS, apparently "blew the mind" of then Deputy Secretary Gates. He considered it inappropriate and "unfair to submit the total problem in its present form," and returned the document to Roy Johnson with this commentary:[16]

> You, yourself, have noted that the overall costs exceed the amounts likely to be available, and it is probably inconceivable that all of the projects could stand up either technically or militarily.

Figure III-3

CORRELATION CHART

Army, Navy, Air Force Operational Requirements		ARPA Supporting Projects by Short Title
I.	Strategic Surveillance (A) Combat Surveillance (A) Signal Intelligence (A) ECM Reconnaissance (N) Recon/Surveillance Sat. Sys. (N) Reconnaissance System (AF)	SAMOS
II.	Low Altitude Space Defense Sys. (A) High Altitude Space Defense Sys. (A) Anti Satellite System (N) Satellite Defense System (AF) Target Satellite (AF)	DEFENDER
III.	Survey and Geodesy (A, N, AF)	MAPPING and GEODESY
IV.	Countermeasures Sat. Sys. (A, N, AF)	SOMNIUM
V.	Earth-Orbiting Military Logistics Base (A, AF) Space Based Surveillance Sys (A, N, AF)	SUZANO
VI.	Earth to Earth Orbit Transportation System (A) Earth Satellite Offensive Weapon System (AF) Sea Based Manned Maneuverable Interceptor Space Craft Weapons Sys. (N) Space Patrol Vehicle (A) Space to Earth Weapons Sys. (A) Advanced Strategic Space Weapon Sys. (AF) Manned Maneuverable Def. Outer Space Vehicles (AF)	MRS. V.
VII.	Communications Satellite Sys. (High/Low) (AF) Communications Satellite Relay Sys. (A) Communications Satellite Sys. (AF)	NOTUS
VIII.	Navigational Satellite Sys. (N) Unmanned Navigation Sat. (AF)	TRANSIT

Figure III-3 (Continued)

Army, Navy, Air Force Operational Requirements		ARPA Supporting Projects by Short Title
IX. Earth Based Surveillance and Control System (A, N, AF)	)	SHEPHERD
Space Based Surveillance and Control System (A, N, AF)	)	
X. Manned, Detection, Warning and Reconnaissance (A, N, AF)	)	MIDAS
XI. Long Range Program for Space Technology (A, N, AF)	)	LONGSIGHT
XII. Target Satellites (A, N, AF)	)	Spent Research and Development Vehicles
XIII. Military Space Logistic Base (A, AF)	)	Space Platform
XIV. Meteorological Satellite Sys. (A, N, AF)	)	By NASA
XV. Manned Lunar Outpost/Base (A, AF)	)	
Manned Maintenance and Resupply Outer Space Vehicle (AF)	)	No specific action by ARPA
Interspace Vehicle (A)	)	
Air/Sea Launch for Satellite Payloads (N)	)	
Lunar and Cislunar Requirements (A, AF)	)	

Source: ARPA, "Long Range Plan for Advanced Research," July 30, 1959.

> I, therefore, suggest that you define the request somewhat further, particularly from a technical, practical point of view, after which we will still be sending too generous a list of requirements for the consideration of the Joint Chiefs of Staff.

ARPA did so, producing an "Abridged Plan" which Secretary McElroy subsequently forwarded to the JCS.[17] The Joint Chiefs in general supported the plan, and lamented the fact that some programs were not funded at the fastest rate permitted by technology (the essence of ARPA's "abridgement" of the plan had been to reduce budget estimates by stretching out program development periods and consequently lengthening estimated operational readiness dates).[18]

A few days after Roy Johnson left ARPA, York, speaking as the DDR&E, refused to honor a Congressional request for the ARPA long range plan in rather blunt terms:[19]

> A tentative Long Range Plan for ARPA's Research and Development Program was prepared some months ago. However, this plan was never approved or implemented and is currently considered obsolete.

As shocking as the total budget implications of the plan were, the estimates were conservative. To do all the things in space that were being talked about would take a commitment to spend billions annually. York stated that DOD no longer intended to plan a discrete military space program; rather all DOD space efforts were to be integrated into other military programs.

Presidential Approval

The ARPA space assignments were divided into two parts, non-military and military. The former involved the on-going scientific satellite programs, which were subject to the one year time limit and express project-by-project Presidential approval provisos of the ARPA authorization legislation. The military satellite programs were considered to be quite separate. Roy Johnson explained this differentiation to the Congress early in 1958:[20]

> I interpret the last part of that clause in Public Law 85-325 to refer to nonmilitary space programs as having only a temporary lease of 1 year. That has been our understanding. So far as military programs with military objectives are concerned, we do not think the 1 year applies.

During its brief period as the directing agency for the scientific satellite program, ARPA received several explicit project assignments direct from President Eisenhower via the Secretary. The ARPA files contain three of them: on March 24, 1958 a series of four Explorer satellite launches, three lunar probes, and the development of a mechanical/ground scanning system for use with the probes; on June 9, 1958, establishment of a minitrack-doppler fence to detect and locate satellites passing over the U.S.; and on July 19, 1958 the large inflatable satellite.[21] The President also personally approved Project ARGUS, which involved the Explorer program and a high altitude nuclear detonation, on May 1, 1958. Later on he personally approved ARPA conduct of Project SCORE, a DOD project devised by Godel and Johnson and motivated by prestige considerations.

The President's interest in ARPA was not pro forma. He personally directed that only ARPA funds would be used for space projects (the Secretary was to prohibit the Services from adding funds of their own) and that they were always to be identified as ARPA projects, not Service projects. This was true for both scientific and military satellites. The public affairs aspects of this issue are discussed more fully below. The President's tenacity is perhaps best illustrated by an incident involving ARPA's policy toward study contracts. ARPA's exclusive right to conduct work in the fields assigned to it, if literally interpreted, would mean prohibiting even small exploratory research studies by the Services. ARPA realized that this was counter productive -- it could not be responsible for all basic and applied research -- and authorized the Services in the summer of 1958 to let contracts for "exploratory studies or feasibility investigations" in ARPA project areas without prior ARPA review, up to a limit of $500,000 ($50,000 for solid propellants).[22] In 1959, ARPA lowered the general limit to $200,000 ($100,000 for solid propellants).[23] The President heard about these exclusions, questioned them, and apparently felt that it was a violation of his ban on Service space projects. He raised it once through General Goodpaster and again personally with Secretary McElroy.[24] It took two lengthy rebuttals, supplemented by direct conversations between York and Kistiakowsky, to convince the President that such flexibility was desirable and to assure him that sufficient controls existed to prevent the Services from generating full-fledged programs out of such studies.

ARPA's staff were intensely aware of the President's interest and this feeling of closeness permeated the Agency's small staff and contributed greatly to its esprit d'corps and sense of mission.

The Scientific Satellites

ARPA's technical contribution to the scientific satellite programs -- Vanguard, the Explorer series, and the Army and Air Force lunar probes --

appears to have been minimal.* It consisted largely of blessing existing plans and working with NACA, NSF, the National Academy of Sciences (NAS), and the Services to resolve bottlenecks and to put together worthwhile new project ideas. Initially, NAS sorted out the priorities among experiments competing for a place in the payloads, NACA and NSF developed the payloads, and DOD was responsible for integration of the project and the launching. After Sputnik the compartmentalization of roles was less precise. Johnson, for instance, commended the IDA staff for assisting in the initiation of the lunar probes, a cosmic ray experiment, and inflatable sphere experiments.[25] Godel believes that an IDA scientist on the ARPA staff made an important contribution to solving the problem of Vanguard blow-ups and an ARPA task force did an evaluation of Vanguard when the Agency inherited that program. We do have evidence that York and Johnson spearheaded a planning effort in the spring of 1958 designed to map out a rational continuation of the scientific satellite program. They solicited both the Services and the concerned civilian agencies for ideas and began to develop a modus operandi for identifying and coordinating the interest of all parties, with emphasis on developing a match between military booster availability and scientific/civilian payload requirements. ARPA's vision at this time was broad. Johnson and York informed Quarles and Killian in June, for example, that ARPA was studying (with NACA/NSF/NAS) the feasibility of both a Mars probe in the summer of 1960 and soft lunar landing vehicles.[26]

ARPA played an important role in the major ARGUS experiment in August 1958 which involved detonation of a 2 kiloton nuclear device over the South Atlantic in the atmosphere, at about 700 km. altitude, to determine whether a high energy electron band would form around the earth and to measure its density.[27] Part of this effort was to insure that Explorer satellites were in position and equipped to observe the effects of the experiment. ARPA succeeded in coordinating the various interested parties in and out of DOD, an achievement that proved to be a forerunner of the role it was later assigned in the nuclear test detection area.

ARPA also argued before a skeptical Deputy Secretary Quarles in behalf of the NACA/U.S. National Committee for the IGY proposals to launch 12 foot and 100 foot inflatable spheres, in part to measure high altitude air density and in part to gain alleged international political

* Note that in the post-Sputnik furor the U.S. scientific satellite program expanded to include Navy (Vanguard), Army (Explorer and lunar probes), and Air Force (lunar probes) participation. Each was ready with projects "to go" and each used its own boosters and other subsystems, and each had or was planning to have its own tracking system. The Secretary could easily foresee similar competition for purely military space projects in the absence of very strong measures at his level.

dividends.* Since a 100-foot sphere at 500 miles would be 2-1/2 times brighter than the brightest star, it was asserted that the U.S. could recoup some lost prestige by launching such a "star." The Operations Coordinating Board endorsed the project on these conventional psychological warfare grounds. Quarles succumbed, and requested and received Presidential approval.[28]

Creation of NASA cut short ARPA's involvement with the scientific satellite programs. Pursuant to Executive Order 10783 of October 1, 1958, ARPA commenced to transfer all of them to NASA. ARPA was probably happy to see them depart. It had inherited from Holaday the responsibility of preparing the monthly reports to the President on these programs and the news for many months was a sorry string of failures and struggles to throw up relatively dainty 5-30 lb. objects.[29]

The Military Satellites

ARPA's influence on the military space programs was considerably greater than it was on the scientific satellite programs. Nonetheless it is virtually impossible to parcel out precise degrees of responsibility either for successes or failures as between ARPA, its Service agents and the laboratories, companies and individuals who worked on the projects. ARPA probably did not "invent" anything and for the most part did not create programs entirely de novo. Virtually all of the satellite programs had been "thought of" in the sense that papers or studies or actual projects were in existence somewhere. The Services seemed to have "requirements" for one of everything, at least on paper, and in many instances could point to some sort of research work, however preliminary. What ARPA did do was decide what was to be supported, what did not deserve support, what might be needed to improve the quality and viability of ideas, what was needed to fill gaps in major programs (and between them), and to serve as a brake on Service and contractor partisans ready to do almost anything (at any cost) to "fly a bird."

It is ironic that the White House and later York were to associate ARPA with profligate spending proposals. Undoubtedly ARPA looked like a band of space promoters from their vantage point, but from an internal DOD perspective ARPA did a remarkable job of rejecting wild ideas and/or supporting others at relatively low levels until they could be safely buried. Criticism of the Administration was rife. Everybody had an idea. Congressmen were eager to promote such ideas in order to help catch up with the Soviets. The Services were only too ready to go along. The

* Dr. Hugh Dryden, Director of NACA, appealed directly to Quarles in a letter July 9, 1958 for DOD support of the 100-foot inflatable sphere. Among other things he noted that Killian's space panel had approved it and that John Pierce of Bell Labs had expressed "great interest."

trade press aimed a steady stream of criticism at the Government for ineptness and tended to glorify every new weapons system scheme that came along. ARPA and IDA staff heard all comers and earned a reputation for both willingness to listen and ability to comprehend. Staff members recall spending hours daily listening to briefings by contractors and Service advocates. Written proposals and suggestions arrived continuously.

ARPA also searched for the common threads which linked outer space research efforts and sought to prevent expensive and unnecessary duplication. This was most important with respect to boosters and their upper stages where there was real danger of competing groups insisting on unique requirements for each major payload type. A similar sort of organizational or management role was discerned and filled by ARPA in the satellite detection and tracking area.

The ARPA military space program management role quickly separated into two parts: (1) carrying out certain projects that were relatively near-term, and (2) planning for the future generation of space satellite projects. The first focussed on satellite-based reconnaissance, missile early warning, navigation, weather observation, and communications. The second identified and considered man-in-space (MIS), the space platform, maneuverable and recoverable space vehicles, electronic countermeasures satellites, and certain exotic concepts such as propulsion systems based on controlled nuclear detonations. Spanning both parts were development of a family of space vehicles and an integrated national tracking system.

One could write volumes on the genesis and evolution of all these projects. We will merely illustrate by example. It is our clear impression that published materials on U.S. rocket and satellite programs definitely underplay ARPA's role (without reference to whether it was good or bad), to the point of ignoring it altogether in most instances. This is probably due to the paucity of written material generally available and some carry-over of the tension between the military and civilian proponents of space during the period.

<u>Reconnaissance Satellites</u>. Reconnaissance is illustrative of the case in which ARPA took over a reasonably well-developed R&D program. The Air Force's Weapons System (WS) 117L program had roots traceable to the famous 1946 Project RAND report that concluded earth satellites were technically feasible.[30] A skeptical military funded an intermittent series of follow-on studies at low levels in the late 1940's and early 1950's in which RAND, and occasionally others, argued that such satellites would be useful militarily for reconnaissance purposes, though not for carrying offensive weapons. Feasibility studies were authorized in 1951 for critical sub-systems such as television (RCA), attitude control (North American), and auxilliary power units (Bendix and Allis Chalmers,

among others). Early in 1955 the Air Force commissioned some design studies from Lockheed, RCA and Martin Co. and it formally established the 117L program in October 1956, with Lockheed and MIT as the dominant hardware development contractors. RCA, rejected by Air Force, submitted an unsolicited proposal to Wernher von Braun to demonstrate the feasibility of using television for weather and surveillance purposes. Von Braun had just been shut out of space by the Quarles decision to make Vanguard the U.S. IGY program, and ABMA quickly awarded RCA a feasibility contract (1956) though the justification shifted in emphasis from RCA's interest in meteorology to Army interest in "target location" (reconnaissance). Von Braun planned to launch the satellite with his Jupiter-C rocket. Early in 1958 ABMA gave RCA a second contract to develop a full fledged reconnaissance satellite, code-named Janus. A month after Sputnik the Secretary of Defense ordered the Air Force to accelerate the WS-117L program "at the maximum rate consistent with good management." A preliminary operations plan was prepared in January-February 1958. At that point ARPA stepped in as manager.*

The Air Force was understandably bitter with the Secretary's decision to remove it from complete authority over the program, especially one with so much national significance. For a time, ARPA even submitted quarterly progress reports on it to the President. Many surmised that Sputnik must have an intelligence function and the surprise Sputnik event itself dramatized the need for improving our own intelligence capabilities. Air Force Secretary Douglas urged McElroy a few days before Roy Johnson's appointment was announced to clarify ARPA's role vis-a-vis 117L.[31] He recommended basically that Air Force continue the project under ARPA's "overall direction." That, in effect, is what happened.

Despite the show of interest, however, the Air Force program had not been well-funded historically and many senior Air Force officers were still known to be primarily interested in aircraft, reluctantly beginning to accept missiles, and not particularly enthusiastic about earth satellites or their military value. Other Services were suspicious of the Air Force possibly obtaining a monopoly on the most advanced intelligence capability and its information. As we have seen, Von Braun already had an Army competitor underway. And although WS 117L was described as an orbiting vehicle capable of collecting and disseminating intelligence information, the Air Force had crammed into it a multiplicity of functions: a visual reconnaissance mission; an electronic reconnaissance mission to detect, measure and process electronic emissions in the electromagnetic spectrum between 50 and 40,000 mc/sec.; an "ICBM attack alarm" mission, using infrared equipment to detect and locate missile

* The official DOD Directive ordering the transfer of all military space projects to ARPA was issued by the Secretary on February 7, 1958.

launchings to a slant range of 2600 miles; and a "capsule recovery" mission that envisioned running biomedical experiments with small primates, i.e., a nascent man-in-space program.[32] In addition, the program had to deal with propulsion, auxilliary power, guidance and control, communications, and data processing subsystems. In short, 117L looked like a completely comprehensive space program in miniature.

ARPA eventually decided that these missions did not necessarily have equal priority or equal degrees of technical complexity, and that they could be more efficiently programmed, budgeted and pursued, if separated into discrete projects. Accordingly, WS 117L was reorganized into SENTRY, for primary reconnaissance missions; MIDAS, to deal with ballistic missile detection; and DISCOVERER, which was described as a technology and techniques-oriented program to experiment with generic problems of satellite launch, orbital injection, stabilization and attitude control in orbit, capsule recovery, etc. that would affect satellite operations in general. Though heatedly denied at the time, DISCOVERER also had some immediate intelligence missions attempting to take advantage of capabilities available then. This was one of the earliest examples of ARPA's close involvement with the intelligence community in areas of very advanced and sophisticated technology. The names WS 117L and SENTRY were later changed to SAMOS because of State Department fears about their military connotations. In fact for much of 1958 the Air Force and its contractors were expressly forbidden to make any references to Weapons System 117L, reconnaissance satellites, SENTRY, or even 'the launching of very large satellites.'* There were a variety of reasons behind the State Department's position: the desire to minimize the appearance that the U.S. accepted, or had joined in, a "space race," especially after the giant Sputnik III was orbited; delicate international negotiations with the Soviets; and uncertainty about questions of sovereignty that might be raised by any use of space for alleged warlike purposes.

ARPA's role vis-a-vis SAMOS, MIDAS and DISCOVERER was complex and varied. On the one hand it had to cope with the desires of Air Force R&D people to charge ahead with work "to put up a bird," whatever the cost. On the other hand ARPA had to persuade a sometimes skeptical DOD front office and an always skeptical BOB (frequently joined by Killian) that large sums were needed. Johnson spoke to Schriever, for instance, about the "often-expressed conviction among certain high Defense Department and Bureau of the Budget officials that WS-117L is becoming excessively expensive."[33] ARPA sought to identify intractable technical problems;

* ARPA specifically directed that Lockheed cancel a big publicity campaign based on its WS 117L participation. (Memorandum for the Secretary of the Air Force from Roy W. Johnson, "Classification of Information on WS-117L, May 19, 1958.) This message was hand delivered to insure receipt.

resist tendencies to sacrifice a superior capability 12 months off in order to achieve an inferior capability in 5 months, with a tremendous waste in resources; and insure that scientific and technical quality were not ignored in the pell mell rush to "do something." It appears, for instance, that ARPA played a major, if somewhat unpopular role, in identifying serious scientific blindspots in the missile early warning satellite program, particularly with respect to the physics of infrared technology. When Air Force sought to balloon the FY 1959 budget for WS 117L from $152 million to $220 million, ARPA negotiated a compromise $185 million program with the Air Force and then argued forcefully for that figure with higher authority. Quarles consistently questioned the ability of complex technical programs to absorb massive infusions of funds, even for high priority programs like SAMOS. ARPA played an especially important role in fleshing out the content of the SAMOS, MIDAS and DISCOVERER programs because simultaneously with the research work, policy-makers at various levels were evolving their thinking about the purposes and uses of these entirely new devices (still not flown), and the technical work in turn had to reflect those emerging desires. Hence ARPA engaged the Services, Killian, Quarles, the Director of CIA and others in a continuing balancing act in which the decision-makers were being educated and making decisions at almost the same time.

Weather Satellites. ARPA played a more direct role than in SAMOS in creating the Tactical Cloud Cover Satellite program later known as TIROS. The 1946 Rand "earthship" study had included a suggestion by L.T. Ridenour for a weather satellite.[34] S. M. Greenfield and W. W. Kellogg produced a very influential paper for RAND in 1951 that examined closely the feasibility of using satellites to make systematic cloud cover observations. RCA contributed to this study and, as noted above, also participated in the early stages of what was to become WS-117L. Kellogg, Fred Singer and several others pursued the weather satellite idea and some elementary cloud cover experiments were included in the Vanguard program.

It was left for ARPA, however, to plan a specific weather R&D satellite program. Dr. Roger S. Warner of the ARPD/IDA staff was attracted to the high quality ABMA/RCA Janus technology, which had been inherited by ARPA along with all other Service space projects, for this purpose. The first ARPA budget drafts, prepared by York, included continued "laboratory development of RCA recon system" as a line item, with the specific notation that a decision to fly it would have to be studied.[35] This line item was retained in subsequent revisions; however, it became clear that WS-117L, not Janus, would form the core of the reconnaissance satellite program. Warner recommended reorienting Janus into a weather satellite and ARPA proceeded to do so. Dr. Richard Chapman had described this event in terms which illustrate beautifully both the level of inter-Service tension which made creation of an ARPA almost inevitable and the serendipitous outcome of the particular way in which this Service feud was controlled:[36]

> The change in mission and the intensity of inter-service rivalry now led to the astonishing requirement that the Huntsville-RCA group degrade the camera resolution of the new, more sophisticated Janus optical system so that the Air Force would be satisfied that Janus was not in fact a "disguised" Army reconnaissance satellite. But the degrading could not be carried below the level of resolution required to serve meteorological observation purposes. The result was that Janus could carry a simpler, lighter optical system, improving its overall reliability. In addition to its television cameras, the revised Janus would carry infrared (IR) sensors to measure water vapor, cloud top temperatures (or, in clear areas, surface temperatures), reflected radiation, and radiation emanating directly from the earth. Spin rockets had to be added to provide a constant spin rate of ten to twelve revolutions per minute (rpm) to maintain satellite stability so that television pictures would not be smeared.

The net technical effect of the constraints imposed by the political compromise* ultimately was a satellite that performed remarkably from its very first launch. That compromise, of course, merely established some rather challenging technical goals. Reaching them was another matter.

The record suggests that ARPA accomplished this task in model fashion. The ARPA project officer, Warner, had worked for Vannevar Bush in OSRD and has shown exceptional skill there in getting scientists and engineers of diverse backgrounds, temperaments and disciplines to work together. In ARPA he proceeded to set up an Ad Hoc Committee on Meteorology chaired by RAND's highly regarded W. W. Kellogg, with a membership drawn from all potential future users and others who had something to contribute. ONR, AFBMD, ABMA, RCA, NACA, the Weather Bureau, and the Army Signal Corps R&D Laboratory were among them. Ostensibly an advisory group, the committee in fact became intimately involved in developing solutions to a wide range of problems presented by the challenge of designing the first weather satellite -- launch vehicles, instrumentation, sensors, even management and contract issues. "Warner's style permitted the committee members to

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* At that time Von Braun and ABMA were happy to accept the compromise because the weather satellite mission looked like the only one that might be left to the Army. By the fall of 1958, ARPA decided to switch from the Army Jupiter to the USAF Thor to launch the weather satellite and changed from ABMA to Air Force Ballistic Missile Division as executive agent. The consequences were minimal because Von Braun's group was then headed for NASA.

feel a full sense of participation in the cloud cover program without detracting from his own responsibility as program manager."[37] To defuse incipient Service rivalries Warner went to great lengths in specifying that ARPA's objective was to test the feasilibity of getting useful weather data, not the design of an operational piece of hardware. RCA's contract called for only one successful launch, orbit and experimental use of a research satellite. Warner also did a masterful job of identifying and bringing in competence from all three Services to work on the project. For instance, ABMA and later AFBMD were responsible for launch facilities and vehicles; NRL was a technical monitor for the whole program and for data handling specifically; Air Force Cambridge Research Center was responsible for the IR equipment and its data output; and the Army Signal Corps R&D Laboratory monitored the satellite vehicle (sensors, power, data storage, and transmission).

The program was a spectacular success. Although it was transferred to NASA (April 1959), the ARPA-planned TIROS I went into orbit and immediately produced usable pictures. In over two months of activity TIROS I produced 23,000 pictures of the earth and its cloud cover, 40 per cent of which could be used. Thus the R&D satellite was almost operational and subsequent improvements evolved it into a highly reliable system. The TIROS experience was to be a forerunner of ARPA's subsequent success with the VELA nuclear test detection research satellites.

The ingredients of success, from the ARPA viewpoint, stand out clearly: a very high quality project officer (Warner); attraction of recognized outside expertise (e.g., Kellogg), with latitude to have influence; knowledge of the whereabouts of the best ideas, people and organizations in industry and DOD (the RCA Janus group, etc.); devising and organizational setting that solicits and uses contributions, rapidly identifies critical problem areas, and makes necessary decisions or interventions when they are needed; delegation of detailed technical and administrative action and monitorship to subordinate groups in the field; and concentration on scientific and technical goals, i.e., on the feasibility of concepts and techniques, rather than the myriad details of "operationalizing" a full blown "system" for use by troops in the field. The fact, in this illustration, that the research product virtually approximated a practical, operational capability was frosting on the cake.

The weather satellite experience is an excellent illustration of what McElroy and Johnson had in mind with their vision of a small, high quality, technically competent, management-oriented organization that could mobilize talents in and out of Defense to test the feasibility of attractive, advanced scientific and technical ideas or concepts without reference to who might use them or the precise conditions under which they would be used.

Most ARPA Directors tend to think of the ideal ARPA in these terms and can recount similar examples. All are aware that ARPA's performance often did not match the model, and that ARPA does not have an exclusive patent on R&D success stories. One cannot say categorically that "only" ARPA can attract good people as staff, or as advisors or consultants, etc.* It is not even clear that its batting average is measurably better than others, such as the Services, although there is some consensus that ARPA has, historically, tended to excel in mobilizing large numbers of first class scientific people in situations where such mobilization is significant. York, for instance, takes the position that the key to success stories like the TIROS example inevitably is the quality of the individual project officer, not his organization. On that criterion ARPA may have an advantage in that OSD level agencies and staffs tend to have better chances at recruiting such individuals due to the more generous allocation of supergrade positions and their obvious bureaucratic placement "closer to the throne."

Other Satellite Programs. Length limitations preclude serious discussion of the navigation and communications satellite programs and the tracking program. The navigation satellite (Transit) was immediately recognized as a tremendous boon to all-weather navigation, especially valuable to Polaris-type systems, and it was moved ahead rapidly. Communications became a tangled subject, for a time a bureaucratic and political nightmare because the Services (esepcially Air Force and Army) competed bitterly for a place in the sun. At one time ARPA had four communications satellite projects on the books, collectively known as NOTUS. Included under that heading were COURIER and STEER-TACKLE-DECREE, the latter threesome usually called ADVENT. ARPA, perhaps unduly influenced by the Service in-fighting, supported the need for interim capabilities, such as a delayed repeater satellite, while working toward

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* In his case study of the weather satellite program under ARPA and NASA, Chapman rates ARPA's leadership skill considerably higher. He notes that NASA's advisory committee, called JMSAC, "was run differently from the former ARPA coordinating committee. NASA retained chairmanship, and as time went on, some participants wryly observed that NASA tried to evoke formal committee support when it suited NASA, yet generally permitted little sense of real participation. NASA's proprietary handling of JMSAC increasingly limited participation in the NIMBUS-TIROS programs by the potential "user" agencies, DOD and the Weather Bureau. The way the committee was run, and NASA's reliance on it as almost the sole means of exchange of information, led to increasing irritation." (Chapman, op. cit., 25). There are plenty of cases in ARPA's history where similar criticisms could be made, i.e., where it failed to match the model.

a longer term 24-hour instantaneous capability. The former really was not needed and the latter emerged in plenty of time -- but that is Monday morning quarterbacking. Many ARPA staff consider ARPA to have been the dominant force in identifying the importance of the 24-hour satellite and insuring that resources were applied to it rapidly.

ARPA's role in satellite detection and tracking involved stitching together an elementary net from partial Service capabilities, preventing the competitors from developing duplicate coverages, integrating the findings from all sources and insuring proper distribution to all users, supporting development of the technically best approach to a long-term national system and cutting off those that had no long-term future. The Agency did an excellent job with this technical task, as well as with the policy issues inherent in the subject matter, i.e., dealing with a function and a system that had "civilian scientific," military and intelligence components.

Launch Vehicles

ARPA made a number of very important decisions relating to the expensive question of launch vehicles for the satellite payloads. It quickly realized that the proliferation of basic boosters and competing designs for the second, third and sometimes fourth stages that they required was becoming a significant drain on both money and manpower. ARPA therefore poured great effort into devising a basic family of vehicles and vehicle combinations designed to meet the majority of plausible payload missions. Among others, Admiral Clark and General Betts (who was then in the Office of the Special Assistant for Guided Missiles) recall this as one of ARPA's most significant achievements. It made for good economics, and because the family would undergo more flight testing for a given cost, vehicle reliability would be increased. This sort of thinking was explained succinctly by Roy Johnson to General Schriever in a letter noting that ARPA might administer work on an upper stage for the Atlas booster differently than it was handling the rest of the Sentry projects:[38]

> ARPA has initiated work on an advanced upper stage for ATLAS, intended both for later reconnaissance payloads and for other ARPA programs. This development will not be managed as part of the SENTRY program but will be closely coordinated with it to insure compatibility with SENTRY requirements. It is my opinion that the economy of developing this stage for multiple uses outweighs the simplicity of management that would result if each system were allowed to develop its own complete inventory of components.

ARPA selected the Agena and Centaur upper stages, in particular, as being the most desirable for mating with Thor and Atlas boosters, and put its money behind them. Centaur was also foreseen in combination with future superthrust boosters. The Centaur selection was especially controversial because it was based on an as yet untried liquid hydrogen technology, but ARPA's judgment was later vindicated by the vehicle's superior performance.* One of ARPA's objectives in moving ahead with Centaur was to give launch pad technicians experience with that technology.[39] The Atlas-Centaur would have the capability to put satellites into 24-hour orbit and lift heavier payloads into other orbit patterns. Centaur was to be the first restartable engine in space and was designed to supply a specific impulse 35 per cent greater than that in conventional rockets. It represented the practical optimization of the weight-lifting potential of ICBM's. York reluctantly transferred Centaur to NASA in 1959. Recognizing its importance to DOD, he insisted on assurances that NASA would pursue the program avidly.

ARPA also decided in its early weeks that a super-thrust booster (1.0-1.5 million pounds) was mandatory for the space needs of the future. Its role in choosing and supporting a candidate is discussed in more detail below.

While not a part of ARPA's recommended vehicle family, the Agency commenced support in its earliest days of a very "advanced" propulsion concept code-name Project ORION. In essence, it was proposed to send large payloads (1000 tons) through space by means of a nuclear-bomb propelled rocket. Low-yield nuclear devices would be triggered at scheduled intervals and the energy from the explosions was to propel the rocket. It was estimated that about 500 explosions would be needed to accelerate the vehicle to orbital velocity.[40] ARPA has, of course, been criticized for support of such a bizarre idea and the incident deserves some explanation. The AEC lobbied hard for the space mission. A few weeks after ARPA was created, the Chairman of the AEC forwarded the ORION idea to Holaday at DOD, noting that the contractor (General Atomic Division of General Dynamics) had been authorized access to nuclear data to work on it.[41] Before long the Assistant Secretary for Research & Engineering, the Secretary's Special Assistant for Atomic Energy, ARPA and Deputy Secretary Quarles had agreed to have ARPA support a feasibility study.[42] Quarles also sought and obtained Killian's endorsement. ARPA working papers suggest that there was substantial doubt that the concept would

* Centaur became a "workhorse" booster, which was to be relied upon well into the 1970's. ARPA's investment in what was very high-risk technology in the late 1950's has been repaid many times and Centaur is cited by some as the greatest technological success story of the Johnson period.

work, but consistent with its charter to look at advanced ideas it was prepared to support experimental work with conventional high explosives. ARPA supported this work at low levels for several years. It probably served to pacify AEC at a time when it was in DOD's interest to do so and it probably also prevented AEC or others from making precipitate moves to spend vast sums on the idea prematurely. ARPA's handling of this idea, and a number of others, had the advantage of (1) demonstrating that an idea was being looked at, professionally, and (2) prevention of unwarranted, expensive systems development.

ARPA's Space Policy Functions

In addition to initiating space programs ARPA immediately became the focal point in DOD for a wide range of space "policy" responsibilities, including the public affairs, security (classification, review and release), and the international aspects of the subject. "Outer space" was so new, so complicated in appearance and content, and endowed with sufficient mystique to make most members of the bureaucracy feel uncomfortable and inadequate in dealing with it. At the same time it was the hottest issue in town, making great demands on time and resources. Consequently ARPA fell heir to a whole host of functions normally carried out by other organizations.

Public Affairs. President Eisenhower was determined to prevent Service competition in space, foreclose Service attempts to use space as a means of augmenting their budgets, and to make space as "peaceful" a place as possible. As noted, his scientific satellite assignments to ARPA were conditioned on the premise that only ARPA would supply the funds and that "the identity of these projects as ARPA projects be maintined throughout."[43] The same public affairs policy was to apply to military satellite programs as well. Especially at the time of satellite launch, Eisenhower wanted tight ARPA control. Thus ARPA, willy-nilly, was drawn into the public relations business. Before long, ARPA was preparing the rather elaborate Public Information Plans that were needed for each launch, in part because it had the only capability in OSD to deal with the technical aspects of the subject, in part because it was closest to the sensitive international policy implications that were involved, and in part because it was the space agency with known clout in the Secretary's office. These "plans" were first-of-a-kind endeavors and required great sensitivity because it was necessary to cope with both security and policy questions and to be prepared for a variety of contingencies, i.e., to explain successes, partial successes and failures. Handled in Godel's office, Rand V. Araskog did a masterful job in perfecting this art. Assistant Secretary of Defense for Public Affairs, Murray Snyder, often complained that ARPA was running an independent public affairs operation -- and indeed it was.*

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* On one occasion, Snyder called for a showdown on a space public affairs launch policy issue before Secretary Gates. L.P. Gise and L.W. Huff were summoned by Gates to give the ARPA case. Snyder lost. ARPA had handled the issue exactly in accordance with Secretarial instructions.

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Security Affairs. The security of space activities presented another major problem. How secret was secret? How much did we want the Soviets to know about the technical aspects of successes or failures? In the rapid exchange world of science and technology, what truly was classified? And how was one to deal with the accepted presumption that the greater the exchange of scientific information, the greater the likelihood of progress? Nobody in normal security review channels in OSD had a grasp of the highly technical subject matter involved. Consequently ARPA was inundated with every speech, article, paper or piece of testimony that dealt with or even mentioned outer space or ballistic missile defense. Furthermore, ARPA had a quicker and clearer grasp of the political and policy considerations that were involved in space and could bring that knowledge to bear. The working relationship between ARPA and OSD Security Review was good, but the burden on ARPA's small staff was quite severe. The Policy and Planning Division handled the procedure, requiring technical staff to review the scientific content and handling the policy aspects itself. Part of the job was to tone down strident Service claims, in accordance with the wishes of the President and the Secretary. As flamboyant as Roy Johnson himself could sound, he appeared conservative next to Service scenarios of the space wars of the future.

Foreign Affairs. The severe crisis of self-doubt which attended the Sputnik event was noted earlier. Space achievement became synonymous with a nation's power and prestige. It was a period when USIA took public opinion polls globally to see whether we were liked and respected, and worried about the results. Space was a common topic at National Security Council (NSC) and Operations Coordinating Board (OCB)* meetings. As a rule, ARPA "staffed" or prepared the Secretary and Deputy Secretary for agenda items dealing with space in both forums, working with ISA. ISA looked to ARPA to handle these issues and the system worked well. ARPA and the JCS provided the DOD representation at the OCB Working Group on Outer Space which struggled for months to draft the first U.S. Policy on Outer Space for the National Security Council. These exercises contained a large quota of silliness -- tremendous arguments, for instance, over whether to state that the United States would seek to be the leader in space. BOB, for instance, was always an opponent of seeking leadership, because it cost money. Nonetheless they served to clarify where the greatest areas of dispute among government agencies lay and to tone down the more extreme views of all the parties. Providing this service for

* The now-defunct OCB was composed of the Under-Secretaries or equivalents of Departments and agencies represented at the NSC and key offices in the Executive Office of the President. Its purpose was to insure that the responsible departments in fact executed the decisions reached by the NSC. The Board was supported by a small staff.

DOD required countless hours of effort in developing and coordinating a DOD view on major policy issues -- soliciting comments from the Services, JCS, ISA, and elsewhere, resolving disputes, directing meetings internally and attending them externally, and numerous direct contacts with State, BOB, NASA, Treasury, the Science Adviser's office, etc. Long after it was clear that "technical" expertise was not crucial to these endeavors and long after the decision to transfer space projects out of ARPA, the Agency was retained in this space policy role. It performed the role well, walking the fine lines between national security, international, and science and technology policy with considerable skill, functioning in that no-man's land between hard line military demands and the basic White House-State Department urge to define space as peaceful and to that end keep the military involvement in it absolutely minimal.

Specific issues often could generate a great deal of heat. For instance, there was State Department concern about the use of Rhesus monkeys in space bio-capsules, given the sacred status of these animals in India. Scientists were alarmed that the Air Force's Project West Ford, which involved orbiting a belt of small metal dipoles or "needles," would be deleterious to the space environment. The list could be lengthened, but the point is that there was remarkably little precedent to go on, the questions were sensitive and the need for resolution usually urgent.

Psychological Operations. Psy Ops or Psy War became a well-developed art as the Cold War progressed. Outer space added a new dimension. Countless suggestions were made about how best to show-up the Russians or recover some of our lost prestige. The OCB coordinated these activities and ARPA, representing DOD, was a principal. Some of it looks positively absurd in retrospect. For instance, a quasi-crackpot letter to McElroy in June 1958 from a citizen in the Bronx proposed that the U.S. secretly install a space vehicle launch pad in the U.K. so that the British could launch a satellite, thereby surprising the Russians and gaining a Free World propaganda victory. The author received a reply from OSD (Office of Public Services), saying that the idea had merit and had been forwarded to ARPA. ARPA sent the letter to the OCB for consideration. Amazingly, a serious reply came back from the OCB staff:[46]

> As you know, the suggestion for assistance to the U.K. in launching a satellite is included in the current policy paper on outer space now under discussion. I think the suggestion [the crackpot letter] could be worked into any Defense proposals which might be made after the policy paper is approved.

This episode conveys some of the flavor of the times. Serious men were serious about what in retrospect can only be regarded as nonsense.

ARPA's major entry in the Psy War sweepstakes was Project SCORE. Conceived by Godel and warmly embraced by Johnson, on purely psychological operations grounds, SCORE had a positive though short-lived impact.

SCORE was a scheme to place a stripped down Atlas booster weighing 9,000 lbs. and a 100 lb. communications payload in an elliptical orbit for a period of about 30 days. The payload was basically a system for broadcasting tape recorded messages. Certain technical objectives consistent with the Atlas development program were alleged, but the main appeal was in the notion that the U.S. could succeed in putting a "heavy satellite" in orbit in 1958, thus countering Soviet propaganda victories based on the Sputnik events and serving as a morale-builder at home. It was defined as a "high risk" project because the hardware involved was still in the prototype development stage.

Quarles obtained Killian's agreement and officially sought Eisenhower's approval in August 1958.[47] The President approved it, but under very stringent instructions. There was to be no pre-launch discussion of the project; if there were any leaks, the whole project would be cancelled;* if it failed during or after launch, it would be explained as an ordinary Atlas missile test launch; and, whatever the outcome, it was to be an ARPA shot, not a Service shot.[48] The White House was adamant about having no pre-launch publicity because the President simply would not tolerate another space failure. The project was carried out on a highly classified need-to-know basis. Indeed it was determined that only 88 people did know about it and Roy Johnson subsequently gave each a certificate of membership in Club 88.

As was customary, ARPA prepared press releases for both a "successful" and an "unsuccessful" launch. To make the latter cover story legitimate, it was necessary to call the launch an <u>Air Force</u> missile test. Since everyone knew ARPA was not in the missile business, that was the only logical way to do it. General Goodpaster, the President's aide, was opposed to that because of Eisenhower's instructions prohibiting Service association with space shots. The issue was brought to the President for resolution. In a meeting with Goodpaster and Godel, the President readily approved the Air Force cover story for the unsuccessful launch contingency.[49] Then he asked if the payload was CW or voice and what message was in it. Told that a voice message from Army Secretary Brucker was to be broadcast, the President said that he would like to put something in the satellite. With blast-off only hours away, the President

* One ARPA staffer believes that at one time everyone in DOD was told that SCORE had been cancelled, then a few key people were instructed to continue working on it in strictest confidence.

recorded a Christmas message on tape which was hand-carried to Cape Canaveral. By then the payload was locked and the missile set for launch. Debate over whether to re-open it was intense because the project manager felt that if he went back out on the pad, the project's cover would be destroyed, which in turn would mean cancellation. The only other option was to try erasing the Brucker message after the payload was in orbit and transmitting the Eisenhower message to the tape recorder. Godel selected the latter option, backed by Johnson, and it worked. As SCORE took off there was some momentary belief that it was going off course and it was actually within one second of being destroyed by the range safety officer. Orbit was achieved, the erasure/transmission accomplished, and the President's message was heard around the world on December 18, 1958.

Technically, it was all a stunt. The weight in orbit was mostly the booster carcass, not usable payload. It was said that this weight matched or exceeded the weight of the large Sputniks, but nobody could be certain. There was some favorable publicity -- Life Magazine was permitted an exclusive story which appeared January 5, 1959 -- but the event was quickly forgotten. The press and some Congressmen, notably Rep. Moss, were highly critical of the pre-launch secrecy policy and ARPA had to take the flak for adhering to the President's policy. Johnson, for instance, had to deny publicly that instructions had been issued to cancel the project if it had become public knowledge prior to launch. Scientists generally scoffed at SCORE. Internally, York thought it was a bum idea both technically and on public relations grounds:[50]

> You see I didn't like SCORE, ever. And that created problems between me and Roy Johnson because it was a favorite of his and a favorite of Godel's. And from their point of view I was just the naive scientist who didn't understand the reality of public relations. From any point of view it was hollow. Because they're going to say that it's the biggest satellite and somebody, somewhere is going to say 'Nuts, it just isn't. It's a big empty shell with a 100 lb. [payload.]'

The engineers who put the bird in the air undoubtedly got a shot in the arm and ARPA, as in the ARGUS experiment, once again demonstrated its ability to organize and direct a special project.

NASA and the Battle for Space Primacy

At exactly the same time that ARPA was attempting to organize itself de novo; bring some order to the stumbling scientific satellite program; define, clarify and direct an immediate military research program in the space and BMD areas; plan a longer term program for the future; and cope with the immense problems of integrating "outer space" into the daily business of government, it was plunged directly into the highly charged political battle over the creation of NASA.

The President's desires to make space a "peaceful place" were well known. The White House science policy apparatus strongly supported that view and tended to equate "peaceful" space research by civilian scientists. The State Department felt it very desirable, from a foreign policy perspective, to play the same tune. It wanted the U.S. to compete with the Soviets, but subtly, and to avoid all public suggestion that the competition was military in purpose. Many others defined the problem in strictly military threat terms and dismissed the White House-State position as verbal posturing at best and more likely a cover-up for Eisenhower's inadequate defense spending. The aerospace trade press was merciless in its attacks throughout 1958-1959.

As the Administration's NASA bill circulated on the Hill, debate focussed on two topics of relevance to the ARPA story. The first concerned definition of civilian and military projects. DOD witnesses noted that there was a large gray area of projects of interest to both agencies, but as time progressed it was felt that these would be sorted out and that for some of them, joint efforts would be undertaken. The second related to a proviso in the Bill's proposed statement of policy section:

> The Congress further declares that such activities should be directed by a civilian agency exercising control over aeronautical and space research sponsored by the United States, except insofar as such activities may be peculiar to or primarily associated with weapons systems or military operations, <u>in which case the agency may act in cooperation with, or on behalf of, the Department of Defense</u>. (Underline added.)

The underlined clause was subject to varying interpretations, the most controversial being that Defense would be subject de facto to NASA veto because it would have to persuade NASA to cooperate or actually undertake work for DOD.

Quarles endorsed the bill and tried to remain faithful to the Administration's proposal, while holding out the prospect of some involvement:[51]

> [W]e believe that there will always be advanced research projects in this particular space area, as well as perhaps in other areas.
> There will be projects appropriate for military control and conduct, and these projects we would expect to continue to be carried on in

> the Advanced Research Projects Agency.
> Just where the line will be drawn, and how the collaboration between Defense and the new NASA will be worked out, I think is the key question before us at this time.

About the strongest statement Quarles made was to say that the military should not be excluded from space.

York, speaking as the ARPA Chief Scientist, was somewhat more forthcoming. He hoped that the law would be interpreted so as to permit ARPA to do some space research and development and not be restricted to specific hardware systems. He made the case that on many occasions scientific developments occurred that had no conceivable military use at first blush, but proved later to have very important national security implications. York's conception of ARPA definitely presupposed considerable license to work in space, or anywhere else:[52]

> ... [I]t is vital for us in maintaining our leadership in the technological area to look as far into the future as we can and grasp at every new idea to see if it has significance in the military sense.
> The primary purpose of the Advanced Research Projects Agency is to take this long look ahead for the Department of Defense on an integrated three service basis and provide a source of new weapons technology from which the weapons systems requirements of the military services can be satisfied. The areas where it is most important to apply this service of ARPA at the moment are that of space technology and in certain aspects of the antiballistic missile field.

York also made it clear that ARPA was proposing and urging a manned space program because it was reasonable to anticipate a future military requirement for a man in space.[53] Although he demurred from entering the dispute over how, legally, to interpret the language in the NASA bill, Senator Lyndon Johnson extracted from York the view that no single agency should control the entire space program and that, if such an agency were civilian, it would impede military development.[54] However, York assumed that ARPA and NASA would cooperate in the future as DOD and NASA had in the past.

All the prancing and pussy-footing around this issue ceased when Roy Johnson took the stand. He blew the lid off with a strongly stated defense of the military role in space and a direct frontal attack on the White House position:[55]

> I believe a civilian astronautics agency should be created with its own funds for use in pursuing its programs. However, military programs already demand the use of outer space for many uses for the protection of our country.
>
> The legislation setting up a civilian group should not be so worded that it may be construed to mean that the military uses of space are to be limited by a civilian agency. This could be disastrous. It behooves the writers of this legislation to state positively this freedom clearly and without equivocation.
>
> For example, if the DOD decides it to be militarily desirable to program for putting man into space, it should not have to justify this activity to this civilian agency.

It was a complete contradiction of Administration policy: asserting an immediate military requirement for using outer space, assailing the notion of a dominant civilian space agency, and demanding that DOD have the right to determine its own space needs and conduct its own programs, independently. The man-in-space example was probably the most inflammable one he could have selected and Johnson made it abundently clear that he had already decided that the military needed manned space missions. The "writers" of the bill whom he lectured in absentia were, in essence, Killian and Eisenhower.

In order to rectify the offending language in the bill, Johnson proposed deleting "peculiar to or primarily associated with weapons systems or military operations" in favor of "in support of or presumed to lead to the use for national defense of weapons systems," and substituting for NASA "may" act, the phrase the NASA "is authorized to act in cooperation with or on behalf of the Department of Defense, if so requested by the Department of Defense." The word changes were a mini-declaration of independence. Johnson felt that DOD should not be restricted by law from pursuing programs critical to the national security, although legally mandated coordination of military and civilian programs made sense to him.

The case he made was simple. Progress in science and technology was cascading, taking both the Soviet Union and ourselves into an unknown future fraught with all manner of weapons system implications. The military had to get there and get there first. Civilians could not be counted on to do it:[56]

> My concern ... is that a military problem is a fast-moving one, and whether civilian-oriented people would be alert to the weapons spectrum possibilities, to the kind of thing that Russia might throw at us on a surprise basis. That would be my concern. I think military-trained people are

> most likely to be exploring the science technology in the terms of weapons, and probably be ahead of the Russians if we continue along the lines we are now going. I would be concerned if a civilian agency, without military background, were to have such a capacity.

The requirements for military investigation and use of space could be quite different, in content and in time frame, than those of the scientists. To Johnson space for peace was "space for fun," and hence an incomplete recognition of the threat posed by the potential use of space by an enemy or self-denial on our part:[57]

> I think it has to be set up with a military connotation, with a full understanding on the part of the public that this is a threat. This isn't something we can sweep under the rug by just saying that it is civilian and ... by saying it is civilian, we can then decide it not a threat. I think we have to realistically face up to a new threat that has been presented to us.

Accordingly the military had to be free to explore all areas of research, even if they could not specify the ultimate military benefit. If the military is supposed to look 5, 10 or 20 years ahead and endeavor to foreclose technological surprise of a military nature, then it must be free to pursue knowledge without artificial boundaries.

Johnson's opening shot took place in the House. Lyndon Johnson explored the issue with him in greater detail in the Senate. In testimony the Senator developed the fascinating fact that the Director of ARPA and his Chief Scientist had not seen the draft NASA bill until 24 hours before its submission to the Congress and thus had been effectively precluded from commenting on it. "I still do not quite understand," said the Senator, "how it happened or why it happened that one holding your responsible place in the Government was not consulted about this particular legislation."[58] Roy Johnson wondered too, and stated flatly that he did not endorse the bill as written. It needed changes and he had proposed corrective language which was then under consideration in the Administration. In pressing his views in DOD he found that the leadership had presumed a simple extension of the old NACA relationship and had missed the Johnson interpretation of the bill's language and intent. Johnson's fears were fed in part by observing the heavy inroads he felt that the nascent NASA, supported by the Killian group and BOB, were making on military interests while negotiating the division of space projects and responsibilities between NASA and ARPA, prusuant to the President's instructions. The immediate decision to hold important disputed areas in the category of "joint projects" pending passage of the bill also supported his suspicions.

Senator Johnson and his Democratic colleagues, and key Republicans such as Senators Saltonstall and Bridges, fell in line with Johnson's testimony and roundly criticized the Administration.[59] The Administration's silent end run around Johnson had added a conspiratorial touch to the whole affair that enhanced the apparent validity of his point of view.

Killian relates that he accepted the idea to elevate NACA to NASA, as suggested to him, independently, by General James McCormick and Dr. James Fisk. He was aware of the keen desires of ARPA, the Air Force and the AEC to get the space mission, but found that PSAC, BOB and Rockefeller's Advisory Committee on Government Operations supported the NASA idea. He, Percival Brundage (BOB) and Rockefeller formally recommended NASA to Eisenhower and the President directed BOB to draw up a bill. Killian concedes that the bill was rushed and that debate on it deliberately was not sought by the Administration. McElroy, Johnson and the Air Force all reacted negatively to the language that pertained to DOD.[60]

After much pulling and hauling, the Space Act was modified to accommodate Johnson's point unambiguously. According to Killian, York tried to adjudicate among the conflicting DOD and White House views. He believed, and argued, that essential military missions should remain in DOD. "He [York] was very explicit and lucid in stating these positions, and so was Quarles." [61] Section 102(b) reads:

> [A]ctivities peculiar to or primarily associated with the development of weapons systems, military operations, or the defense of the United States (including the research and development necessary to make effective provision for the defense of the United States) shall be the responsibility of, and shall be directed by, the Department of Defense....

The new ARPA Director had won a smashing personal victory. Depending on your point of view, his performance was courageous or foolish, perhaps some of each. Senator Johnson congratulated him on his independence, and he responded:[62]

> I understand that even though we are employed within the Government that when we testify before this committee, that we are supposed to tell what we really think and of course I do not know whether I will have a job when I leave here today, but I am saying what I think.

He was not fired, but the victory was costly in many respects. Johnson had incurred the wrath of the White House. He had broken with the Administration and embarrassed it. He had also compromised the Secretary and

Deputy Secretary to some extent (though McElroy publicly backed Johnson's position). Some of the flavor of the strain placed on the McElroy/Quarles relationship is reflected in an unusually formal memorandum that Johnson sent to the Secretary after the battle had raged well into the summer.[63]

> The General Counsel has advised you that the Director of the Advanced Research Projects Agency is very enthusiastic about the space legislation which establishes what I believe to be a good mechanism for instituting and monitoring a national space program. I understand this will be signed by the President momentarily. The enabling language permitting the Department of Defense to work very broadly in the field of space was very desirable. I believe any doubts that existed with regard to the Department of Defense proceeding with the military program outlined in my letters to you of July 2 and July 9 have been removed.*

Relations with the Killian group, especially, deteriorated. Johnson, and thenceforth ARPA, were decidedly suspect in that quarter. It was a difficult burden to bear while trying simultaneously to create, justify and obtain DOD and Administration support for an as yet unformulated ARPA program. Periodic pro-military outbursts by ARPA and IDA personnel were reported in the trade press and served to reconfirm ARPA's apparent intransigence.[64] Of greater moment, ARPA was stigmatized as untrustworthy in the eyes of the science policy-makers at the White House who, theoretically, ought to have been developed as its priority clientele and source of support. ARPA, as an institution, never fully managed to throw off this unfortunate image.

Within ARPA, many staff members resented the creation of NASA, especially the ARPD/IDA group. Johnson felt compelled to circulate a strongly worded two page memorandum to the staff insisting that the Space Act and NASA be given every support by ARPA and IDA personnel.[65] He also sent a copy to McElroy and Quarles, presumably to reassure them that he was "back on the team."**

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* The Secretary returned his copy with a handwritten note, dated August 3, 1958: "Mr. Roy Johnson: I believe these questions have now been resolved. Am I right?"

** They returned the memorandum to Johnson with the following notations: Quarles -- "Agree;" McElroy -- "Good!" Illustrating continuing strains between NASA and ARPA, however, the memorandum was recirculated among the ARPA staff as a "reminder" on at least one later occasion.

ARPA's Long-Term Space Program Concept

Aside from the immediate satellite projects and their requirements for adequate propulsion and tracking support, ARPA moved to develop a forward look at outer space. The core features of the ARPA vision of the future were man-in-space, the super thrust booster, space platforms, and the maneuverable, recoverable space vehicle (code named MRS-V). Obviously, these concepts are central elements of the NASA program up to the present day. They appear in the earliest ARPA documents and were rapidly developed into a proposed ARPA program by York, the IDA staff and the cadre of officers assigned to ARPA.

Man-in-Space (MIS). The prospect of putting a man in space was at the forefront of ARPA thinking from the minute it began. The earliest draft of an ARPA budget that we could locate (prepared by York on March 4, 1958) listed an animal flight and recovery program and $5-20 million to begin unspecified preparations for manned space flight. A formal program submission to the Secretary two weeks later added a specific Army proposal then called the Man Very High Program.[66] Intelligence estimates at the time anticipated a Soviet manned launch by 1960 (Gagarin's 1 hour and 48 minute single orbit flight occurred in April 1961). The Services and their contractors each had manned space proposals to offer and the contractors concocted some of their own. Roy Johnson noted that the Agency seriously reviewed 12-15 manned space proposals in the course of preparing the FY 1959 budget estimate alone. ARPA's role as the decision-maker was confirmed by Quarles in responding to an Army attempt to get direct Secretarial approval for an MIS scheme in August 1958:[67]

> Per conversation with Mr. Roy Johnson: ARPA will be the Defense Agency for such projects, for undertaking them, for rejecting them, or for referring them to the National Space Council for disposition.

The Navy, assisted by Convair, Goodyear, Martin, Boeing, and Marquardt, promoted two man-in-space projects code-named MER and FLY-UP. The Navy coyly noted that the Bureau of Aeronautics had undertaken these projects "as a contribution to an unknown national space agency and now with the formation of ARPA suggested that they might properly be taken under its auspices for future development."[68] MER involved boosting a man into orbit with a large rocket in a collapsible pneumatic glider which would be inflated in orbit and flown down to a water landing. It was rejected because the booster requirement was excessive and a special materials development program was needed both for the glider fabric and the wing leading edge. FLY-UP proposed using a liquid air cycle engine as a booster.* It had no appeal to ARPA.

* Navy later attempted a quite different FLY-UP Satellite project involving use of a F4D aircraft to launch a rocket containing a small 2 lb. satellite.

The Army was keen on Project ADAM, a scheme to boost a man in a recoverable capsule via a Redstone on a ballistic trajectory to a height of 150 miles and a downrange distance of 150 miles. It was argued that the U.S. would have a space "first;" valuable bio-medical data would result, e.g., man would be subjected to a ten minute period of weightlessness; and that ADAM would lead to development of a special transport capability for sabotage, guerrilla, unconventional warfare, and messenger-type missions; missions which appeared rather far-fetched on cost-effectiveness grounds, to say the least.[69] Allan Dulles, then Director of CIA, also was interested in this technique and agreed to support any DOD effort to get Presidential approval for the project. ARPA rejected the idea because the "space first" achievement was moot (the Soviets had already recovered a dog from a vertical rocket firing at twice the altitude of ADAM and were displaying the recovery capsule at the Brussels Trade Fair; with that experience plus higher performance rockets, it was felt they could recover a man handily); bio-medical information was anticipated from the X-15 program and DISCOVERER; and ARPA was unconvinced about the alleged "transport" requirement of interest to the Army and Dulles.

The Air Force approach made the most sense to ARPA. In one of his very first memoranda, Johnson affirmed that the Air Force had "a recognized long term development responsibility for manned space flight capability with the primary objective of accomplished satellite flight as soon as technology permits."[70] As noted, the DISCOVERER program included some bio-medical capsule recovery experiments, and in May 1958 Air Force proposed its "Man in Space Soonest" project. In essence, Air Force would send up a man on an ICBM booster fitted with a suitable upper stage, observe his capacity to function in space, and recover him in a ballistic reentry initiated by retro-rockets. A beacon and other devices would be used to locate him and a parachute would be used to slow down the capsule to a safe landing speed. ARPA eventually adopted a plan based on this concept, envisioning a progression from small recoverable capsules through medium-sized packages, to man-carrying vehicles.[71] The ARPA work was directed by S. M. Batdorf of the IDA staff, who chaired a specific Man-in-Space Panel. Prior to NASA's creation, Batdorf's Panel included a NACA member.

Johnson and York identified man-in-space as a matter of great interest in their first appearance before the House DOD Appropriations Subcommittee. It was listed first in the budget under the category of "Military Developments for and Applications of Space Technology," although both men acknowledged that the pending NASA legislation placed it in a gray area and that some people felt it should be a civilian program. York was very positive about man in space and ARPA's authority over it in DOD. He was vague about its placement as between ARPA and the as yet uncreated NASA. York testified that MIS fit Johnson's criterion for an

ARPA project perfectly, i.e., the whole subject was in a pre-military requirements status:[72]

> And the reason that we cannot see these requirements, or spell them out in detail, I think is not because they do not exist, but just because we are not smart enough, and neither is anyone else, to see what they are. So we are proposing and urging a man in space program on the grounds that we think it is reasonable to believe there will be a military requirement sometime for man in space, even though we cannot spell it out, and it is better to undertake these things, to have a deliberate program now than it is to have a crash program later when the requirement can in detail be spelled out. We have been caught before on this matter of waiting too long before we got going on it.

York surmised that probably the ultimate justification for sending men into space would be cost effectiveness, i.e., a point would be reached at which it would be cheaper to send a man up to repair orbiting satellites than to launch new ones. As for lunar and planetary exploration, he believed that machines would never be an adequate substitute for man. Thus he supported an aggressive and deliberate MIS program, but not a crash program.

Toward the end of 1958 York prepared a ten year space forecast, endorsed by Johnson and Clark, for Congressman John W. McCormick, then Chairman of the Select Committee on Astronautics and Space Exploration. He predicted the safe orbit and return of a manned capsule within a few years (the first U.S. suborbital flight took place in May 1961); a space vehicle capable of maneuvering in space, rendezvousing with other satellites, and maneuvering in the atmosphere by 1968 (the first manned orbital maneuvers and rendezvous commenced in the Gemini program in 1965); and a manned lunar landing in 1968 (Armstrong stepped on the moon July 16, 1969). The only capability not yet achieved is the maneuverable landing. York said that: "The space-pilot, on return, will be able to land at an airstrip on the earth more or less of his own choosing. Man will be performing numerous essential tasks in connection with the various missions and applications given below," including reconnaissance communications, missile early warning, weather observation, navigation, environmental studies, etc.[73]

Johnson accepted this rationale and became an unyielding advocate of a <u>military</u> manned space flight program. The Cesaro-Youngquist paper also contained an especially emotional plea for a strong military space program, with man at the heart of it. Johnson was soon arguing the case with McElroy and Quarles for manned strategic orbital delivery systems and manned surveillance systems, and suggesting the possibility even of future moon bases:[74]

> The Department of Defense must have the capability to freely exploit the military use of space and the attendant research and development associated with vital potential military systems. The United States must develop a capability to deny use of space to potential enemies in the event of war. The United States cannot afford to have USSR exploit the technical and military aspects of space operations without doing likewise. Man will be an important element in the development of space based operations. The man-in-space program is a building block on which the future progress of many of these programs must rest.

A special effort was made to convince Killian that a legitimate military man in space requirement existed. Discussions were held with him and a special paper submitted with this cover note:[75]

> We have considered this problem very carefully, and feel that the arguments propounded herein are valid. A decision to authorize the Defense Department to proceed with work leading to these necessary developments will, we believe, be in the best interest of economy and national security.

The ARPA paper sent to Killian with this note asserted that a manned capability was needed for virtually every conceivable purpose from reconnaissance and navigation to "counteroffensive bombardment of both strategic and tactical targets." Humans were determined to be infinitely superior to machines in detecting, analyzing and observing the enemy and his activities. Manned operations would prove to be more economical and would permit satellite repair and maintenance. Men based on platforms could launch satellites from those platforms to extremely high altitudes without having to accommodate atmospheric traits or elaborate ground launch facilities. Interception of enemy satellites would be facilitated. The Soviets were going to do all these things and so should we. In addition to this litany of alleged "strategic" considerations a much more practical set of points was made, revolving around DOD's massive investment in rocket production facilities; ground facilities (ranges, launching, tracking and telemetry, world wide communications, recovery ship and aircraft, etc.); and the manpower, organizational and management capabilities of the military departments.

Unstated in the paper to Killian, but very much in the forefront of ARPA thinking, was the question of competence and sense of urgency. Experience with NACA-type arrangements had created the stereotype of a bunch of well-meaning but short-sighted applied scientists interested in hobby horses, but without sufficient technical breadth, imagination, awareness of practical (military) applications, and above all drive to ever finish the job. This stereotype deeply troubled Johnson and his colleagues.

The appeal to Killian was, in Johnson's terms, a failure. The White House was absolutely committed to a peaceful uses of outer space theme. The President had released the PSAC report "Introduction to Outer Space," with a strong personal endorsement on March 26, 1958. This "space primer" downplayed the military value of space and spoke of it almost entirely in terms of advancing our knowledge of scientific phenomena, the solar system and the universe, eventually leading to helpful payoffs in fields such as weather forecasting and communications. DOD could accept this rationalization, provided it did not stand in the way of military R&D. The President's "Special Message to the Congress Relative to Space Science and Exploration" on April 2, 1958 -- the day after Johnson arrived in ARPA on a full time basis -- made it clear, however, that the President was in earnest. He insisted that a civilian agency have the dominant role in space. Roy Johnson was just as adamant that McElroy had set up ARPA precisely because of the various military implications suggested by the Russian presence there, but he was powerless to reverse the decision. The "Introduction to Outer Space" also said that "It would not be in the national interest to exploit space science at the cost of weakening our efforts in other scientific endeavor."[76] In the Pentagon this was read as "business as usual" and was taken to mean that the civilian science cadre was naive and insensitive to national security considerations. Johnson articulated this view in a blistering indictment of the scientists:[77]

> I suggest that the Congress should not blindly accept all of the advice from eminent scientists. Many of these competent men of science are not competent to advise our country in matters of national security, policymaking, or general management. As an example, I believe we lag in the missile and space fields because of bad advice given over the past dozen years.

As Killian and Kistiskowsky tried to sit on the total space program budget, the military became firmly convinced that the civilians were massively resistent to the needs of the times. A tremendous hostility, unrelieved by contact, thus built up. Johnson let his bitterness spill over in testimony before the House Committee on Science and Astronautics several months after he had returned to private life:[78]

> I believe there is one fairly sinister development which you could help, perhaps, to overcome. There is a widespread, almost emotional movement to declare space, like Antartica, a peaceful place. This is as hopeless of being effective as declaring the ground, the air or the water exclusively peaceful.... This idea that there is no purpose for a man in space, that was enunciated, I think, as a part of the President's primer that there is no reason to have a man in space, I have disagreed with that statement, violently disagreed with that statement. Yet that statement is constantly being made. There again, eminent scientists continue to talk this way, and I am greatly concerned why they must insist on this. What is wrong with a man in uniform being in space?

The scientific elite was willing to have a man-in-space effort, but on the basis of a long-term scientific research program. Moon bases, manned orbital weapons systems and GI astro-mechanics were dismissed as absurd. No manned military mission would be authorized. On the other hand, it was undeniable that military capabilities were needed to run any meaningful program to put a man in space, whatever the timetable, for everything from astronauts to the thousands of men needed to be deployed globally to get them back.

Johnson, seeing an exclusive DOD program ruled out, lobbied awhile for a separate DOD program and eventually had to settle for a joint one with NASA as the senior partner. The record shows a variety of attempts by ARPA to control or dominate the "joint" program, but NASA could always muster enough support to narrow down ARPA's involvement.[79] ARPA hoped to share the budget burden 50/50 but could not get the money. By August 1959, responsibility for DOD support of Project MERCURY had been assigned to the Air Force. ARPA's exclusion was sealed by a Memorandum of Understanding, "Program for a Manned Orbital Vehicle" which Glennan and Johnson signed on January 20, 1959. The key clause: "$8,000,000 of FY 1959 funds will be contributed by ARPA in support of the program and will be made available by appropriation transfer to NASA. NASA will budget for and fund all subsequent years' costs."

Histories of the U.S. man-in-space program rarely mention ARPA, much less consider that it had anything to do with its substance. ARPA saw it differently:[80]

> The planning for this [man in space] was done in cooperation with the Air Force, the Office of the Secretary of Defense and the National Aeronautics and Space Administration. The NASA, as a matter of fact,

had not been, as yet, created by law but it was anticipated that it would be and that the responsibility for this first phase of man-in-space would probably be either shared with NASA or transferred to it entirely after the Bill was passed. NASA was requested to designate a delegate to be a member of the Man-in-Space Panel and participate in all deliberations. By this means, it was hoped that should a shift in responsibility occur, the minimum change of direction would occur.

At an early meeting of the National Aeronautics and Space Council, it was decided that the responsibility for the first phase of man-in-space would be a split one, with NASA in the senior role. Seventy-five percent of the available budget for this project was given to NASA and twenty-five percent to ARPA. In order to simplify the administrative aspects of the cooperative effort, Mr. Johnson and Dr. Glennan agreed that the ARPA budget for the first phase would be transferred to NASA, and that a Joint Working Committee would be set up to handle the broad planning. The project was placed under Mr. Robert Gilruth of NASA.

In the program that finally emerged, the objectives remained the same -- namely, to develop a suitable bio-capsule to place a man in orbit, in this capsule, and to observe his capacity to live and function there, and to recover the man and package safely. The development plan changed in some respects. The most notable change was a decision to do all experiments with a full-sized capsule. First, dummy capsules would be dropped from helicopters and aircraft to check landing conditions. Then capsules would be projected by a rocket at gradually increasing speeds through gradually increasing ranges always effecting recovery until finally orbit was achieved, together with recovery from orbit.

Emme's history of space flight merely notes that "the NACA proposal for a ballistic spacecraft for manned orbital flight" was selected by NASA as the basis for Project MERCURY.[81]

It should be stressed that unhappiness over the loss of Man-in-Space did not cause Johnson to oppose or impede NASA. On the contrary, he wrote Administrator-Designate Glennan a month before NASA began to operate, that he was troubled about their joint MIS project because the two budgets, collectively (ARPA - $10 million and NASA - $30 million) were too small:[82]

> My concern over this project is due (1) to a firm conviction, backed by intelligence briefings, that the Soviet's next spectacular effort in space will be to orbit a human, and (2) that the amount of $40 million for FY 1959 is woefully inadequate to compete with the Russian program. As you know our best estimates (based on some 12 - 15 plans) were $100 to $150 million for an optimum FY 1959 program.
>
> I am convinced that the military and psychological impact on the United States and its Allies of a successful Soviet man-in-space "first" program would be far reaching and of great consequence.
>
> Because of this deep conviction, I feel that no time should be lost in launching an aggressive Man-in-Space program and that we should be prepared if the situation warrants, to request supplemental appropriations of the Congress in January to pursue the program with the utmost urgency.

After Glennan kicked off Project MERCURY on October 7, 1958, his first week in office, Johnson proposed that they seek emergency funds from the Secretary of Defense. There were two reasons: (1) Johnson genuinely wanted a man in space, regardless of who did it, and (2) he also felt that Sec. 102(b) of the Space Act gave DOD the right to pursue a separate program, for its purposes. Not a devious man, Johnson clearly had man-in-space in mind when he had argued for changes in the space bill's language:[83]

> I think in writing that particular sentence I had in mind the kind of program that would involve getting man into space. I think that it is very necessary to have complete coordination with all agencies who are interested in doing this, but I do believe it is very important to allow the military agencies to participate and direct their interest so that in the event it becomes necessary militarily to have a man up there, we have paved the groundwork, and there may be different environment necessary for a man for that reason than a man who is exploring space just for fun.

The very last clause in the last sentence in the quotation is important: a science-based program, conducted by scientists on a restricted budget would not be adequate. The military point of view was quite separate and deserved to be supported. While NASA took the "capsule recovery" route, Johnson told Glennan, DOD would follow the boost glide DYNA-SOAR approach being promoted by the Air Force. Johnson was also gearing up to initiate the SATURN project, which would give DOD the booster capability for manned missions.

Super Thrust Boosters.* The key to Soviet success with Sputnik was its giant booster. Needless to say, analysis of booster requirements was a topic of great interest throughout DOD. As thinking about outer space crystallized, it became apparent that a super thrust engine might be needed, especially for manned space missions. ARPA lobbied for the assignment and received it on June 23, 1958.[84]

> [R]esponsibility for advanced research and development on new super-thrust rocket engines (including the currently conceived "million pound thrust" engine) is assigned to the Director of the Advanced Research Projects Agency. This assignment includes feasibility studies, design and prototype of the engine, consideration and possible development of new propellants, and consideration of the interrelationship of the engine and the vehicles to be carried by it.

ARPA was aware of an Air Force research study effort to design a single chamber one million pound thrust engine but concluded that it was a long term project. Feeling that a super thrust capability would be needed much sooner if the U.S. was to catch up and keep pace with the Soviets, ARPA began to search for alternatives. This led to conceptualization of the SATURN project, one of the most controversial in ARPA's history.

From the ARPA vantage point, ARPA staff (specifically David A. Young and Richard Canright of IDA) conceived the notion of clustering 7-9 available IRBM-type engines to yield a 1.5 million lb. thrust booster.** With Johnson's approval, Young approach Von Braun and others at ABMA about the idea. They were lukewarm initially, apparently for budgetary rather than technical reasons. Von Braun countered with the results of an

* The information in this section is drawn primarily from the testimony of Roy W. Johnson before the House Committee on Science and Astronautics, March 30, 1960. Johnson's testimony on that occasion took the form of a highly detailed chronology of the SATURN project based on his private notes and diary. The reader thus sees the super thrust booster issue through ARPA eyes.

** Rocket histories usually attribute this idea to the Von Braun team which, at the least, definitely was studying the concept of clustering. Senior ARPA staff from the 1958 period, such as Clark and Lay, cannot absolutely confirm that the ARPD/IDA staff literally invented the 7-9 rocket cluster notion, but are inclined to think that they did. Whatever its ancestry, ARPA fought incessantly for the project. (Cf. Wernher Von Braun, "The Redstone, Jupiter and Juno," in Eugene M. Emme (ed.), the History of Rocket Technology (Detroit: Wayne State, 1964) 119 ff.

ABMA study for a cluster of four engines, but these engines were still in the development process. He liked the eight-engine cluster idea because one engine could fail and the booster would still function. Von Braun accepted the ARPA proposal and ARPA issued ARPA Order 14-59 to ABMA on August 15, 1958 to move ahead with it. The first draft of ARPA's FY 1960 budget request contained $40 million for Saturn and $14 million for its guidance system.

Johnson saw this booster, soon known as the SATURN IB, as essential to man-in-space, but most of the paper justification was based on an alleged initial military use for placing a heavy (8-10,000 lb.) communications satellite package in a stationary, 22,000 mile or 24-hour orbit, followed by mention of other "identified military requirements for placing large payloads in orbit at the earliest possible date," namely, advanced reconnaissance systems, satellite control systems, satellite-based BMD warning and attack systems, space platforms, maneuverable, recoverable space vehicles, and advanced strategic space weapon systems.[85] During part of the SATURN project's lifetime, ARPA staff recall that it was seriously affected by the President's "peaceful use of outer space" campaign. Incensed at continual DOD discussion of military man-in-space, they indicate that for a time DOD was forbidden even to mention the phrase "Man-in-space."[86] The trade press insisted that the Administration had drawn a line at 600 miles, beyond which the military could not go, thereby defining away military justification for projects like the SATURN: "From 600 miles out, space belongs to NASA and the Russians."[87] In any event, the MIS curb meant that the presumed "real" need for SATURN, putting man in space and on the moon, could not be used. The "24 hour orbit heavy payload" requirement, while probably generated in good faith initially, was carried on the books long after it was clear in ARPA that it really was not valid.[88] There is even some lingering suspicion that this "requirement" for SATURN was fabricated from the beginning.

During this period -- summer and fall of 1958 -- both NASA and a national space program were being established. NASA indicated an interest in acquiring SATURN. In the course of a key budget review meeting in November -- attended by Killian, Quarles, Glennan, Dryden, York, Gise, and David Young, but not Johnson -- all money for SATURN was deleted from the budget and the question of perhaps transferring such responsibility to NASA was raised. The transfer idea was opposed by ARPA and, according to Johnson, was not urged by Glennan on this occasion. No action was taken. Johnson campaigned hard for restoration of funds and his persistence overcame Quarles, who reinstated the money. ARPA also urged Schriever to explore the possibility of wedding WS-117L payloads to SATURN, a marriage that never was consummated.

Nonetheless, Johnson was on a downhill slide with SATURN. His case appears to have had three parts. First, a sincere belief that rapid achievement of manned space flight depended on a large booster, matched by a feeling that NASA would take too long to develop one like it. The latter feeling probably was intensified when NASA decided to develop the single chamber super thrust booster concept called NOVA, i.e., the longer term alternative. Second, a decision, perhaps implicitly arrived at, to consider the SATURN case as a symbol of the civilian vs. military uses of outer space dispute. It was customary for Johnson to appeal directly to Section 102(b) of the National Aeronautics and Space Act, which authorized a military role in space, in arguing for SATURN:[89]

> It is ARPA's position that this program to develop a 1.5 million pound clustered booster is authorized by the act since it is required to fulfill early military requirements. Examples of such requirements are the large, high altitude communications satellite and the manned reusable space vehicle.

He wanted to win a clear cut victory for DOD on a major disputed project in order to make sure that the Sec. 102(b) language had meaning. And third, a genuine feeling that an immediate super thrust capability was urgently needed and that the Saturn concept was the most economical and practical way to achieve it. ARPA argued that compared to the single chamber engine, SATURN was preferable because: (1) it represented a simple extension of the state of the art, (2) used reliable and available components, (3) could be available two or three years ahead of the single chamber model, and (4) utilized existing competence at ABMA.[90] This argument was Johnson's best, provided the "urgency" assumption was correct. The comparison of SATURN and NOVA had been very carefully done in ARPA. Indeed the conclusions were shared by Rocketdyne which was working on both rockets. Rocketdyne considered that SATURN would be available sooner and would initially be cheaper, whereas NOVA would be a higher performance vehicle and ultimately more reliable.[91] In support of his position, Johnson noted that the Chairman of the DOD-NASA Civilian Military Liaison Committee (Holaday) had reaffirmed both the original decision to proceed with SATURN IB and the recommendation of the SATURN, NOVA, DYNA-SOAR/TITAN Ad Hoc Booster Committee to give SATURN a higher priority than NOVA.[92] In brief, SATURN was of "the utmost national importance" to Johnson because he felt that it alone had the potential to meet DOD and NASA heavy payload requirements in the period 1963-1968 and to demonstrate a propulsion achievement comparable to the Soviets. He was not the only believer, and certainly not the most outspoken as illustrated by the following trade press commentary:[93]

> ... The date of the transfer of the SATURN program from the Pentagon to NASA may go down in history as the point when the United States firmly committed itself to being a second-class military space power....

> It also will mark the end of the frustrating saga of a Pentagon attempt to make the United States a first-class military space power despite the hobbling restrictions placed on it by the Administration....
>
> Without question, the acrid smell in Pentagon corridors these days is caused by the smoke from the burning of the military bridge to the moon and space.

Accordingly, this article concluded, the Soviets would dominate "the moon and most of cislunar space."

Johnson fought a strong rearguard action throughout 1959. Inside DOD, York (and others) opposed SATURN IB because he felt that there were no military requirements* for it and that the single thrust engine would appear in sufficient time to accommodate the man in space program. PSAC felt the same way and BOB was always suspicious of military urgency as a justification. York was, of course, proven by events to be absolutely correct. As the DDR&E he actually cancelled SATURN IB once, then reinstated it. Johnson gave this view of York's cancellation decision:[94]

> The views of Dr.Kistiakowsky, Ralph Clark, and others that the military communications requirements of the Defense Department could better be satisfied by the launching of a substantial series of smaller 24-hour vehicles convinced Dr. York that SATURN, per se, was not required by the Defense Department for the accommodation of its military requirements. SATURN has been primarily defended since the establishment of NASA as a military vehicle required for the communications mission.
>
> Dr. York has never concurred with the proposition that SATURN is necessary because he does not believe space platforms and MRS-V have military applications.

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* The Services, encouraged by ARPA and supported by JCS, manufactured oodles of "requirements" for space platforms, space patrol air defense systems and countless other things, all of which "needed" super boosters, but making them stick in a budget -- the ultimate test of validity -- was a much harder proposition. (For example, Memorandum for the Acting Secretary of Defense from Col. Edwin F. Black, Military Assistant, "Requirements for Large Boosters," January 9, 1959.) It seems fair to say that ARPA was neither helped nor hindered by the presence or absence of such "requirements."

Whatever the merit of the Kistiakowsky-Clark attribution, this is an accurate statement of York's position. York's official cancellation notice to Johnson said that SATURN had no existing military justification, that any future military requirement could be met by the proposed USAF Titan-C, and that "by the cancellation the Defense Department will be in a position to terminate the costly operation being conducted at ABMA." Johnson said that if York had his facts right about Titan-C, he would have to support the decision and in turn suggested transferring SATURN and the Von Braun team to the Air Force. There was a great hullabaloo raised about York's transfer decision in the world populated by scientists and space technology people in the Services, NASA, industry, and elsewhere. Under pressure, York agreed to a full-fledged technical review of the TITAN C, SATURN and NOVA.* ARPA provided office space for the reviewers. Presentations were heard from many interested parties including ARPA, NASA, Air Force, and Army. After the review, York reversed himself and approved SATURN. According to Johnson, he did this on the basis of ARPA testimony. Shortly thereafter, however, York negotiated the transfer of SATURN to NASA, albeit insisting throughout that there must be a firm Presidential commitment to fund SATURN. Johnson said that both he and Deputy Secretary Gates were perplexed by the apparent conflict between the positions that: (a) there was no military requirement for SATURN, but (b) SATURN must be funded before DOD would let it go.[95]

Looking back on this matter sixteen years later, York explained his decision essentially in terms of political feasibility:[96]

> I was always very much in favor of what we call the SATURN today, but then we called it the NOVA. I came to favor a program that would include a bigger type as the next step, actually a four barrel type which is very similar, not identical but similar, to what is now the TITAN III.... At the same time I was in favor of transferring all of the responsibility for those big rockets to NASA and I was in favor of transferring Von Braun to NASA. Now, I soon came to realize that I couldn't achieve all of those, and so I gave up on the particular technological detail of having the TITAN III instead of the SATURN IB because the other two were in my mind much more important. I talked with Wernher himself about that, and it became evident at that time that I might be able to get any two of the three, but I sure couldn't get 'em all, so I gave up on the unimportant one."

The SATURN transfer decision, taking it out of ARPA and out of DOD, was a crushing blow to Johnson and to many within the Agency. It was

* York and Dryden were co-chairmen of the review committee.

ARPA's baby; it seemed so essential to achieving that urgent parity with the Soviets that ARPA originally had been set up to do and that Johnson had been told he could count on doing with the highest level support; and to Roy Johnson it was the key to a military program involving manned space flight, space platforms and maneuverable, recoverable vehicles. By denying a military need for SATURN, one automatically denied all the others. All of Johnson's associates agree that SATURN was a passion for him: he had approved initiating it, he had kept it alive in the face of serious budget opposition from BOB and others, he fought for its retention within DOD, and he was publicly to challenge the Administration on it. As one of them put it: "SATURN was the biggest [personal] Roy Johnson contribution and he did it over the dead, dying and bleeding bodies of just about everybody."[97] With York and Quarles opposed, not to mention NASA and the Science Adviser's office, he was unable to persuade a lame duck McElroy and ultimately lost the battle.

Nonetheless, as the SATURN transfer decision reached its climax, Johnson and Von Braun teamed up in a classic challenge to the Administration's desires by staging a well-attended press encounter, just prior to entering a meeting with Glennan on the planned transfer of ABMA. It was two weeks prior to Johnson's announced departure from ARPA. Von Braun presented Johnson with a giant scale model of SATURN and the two men urged a two-year acceleration of the program and an additional $100 million.[98] The Administration had already doubled SATURN spending over the previous year and also had rejected the extra $100 million request. But Johnson and Von Braun "went public," knowing they were embarrassing York, McElroy and the President. They also reiterated their belief that there was a military requirement for SATURN. ARPA staff admired Johnson for his courage -- right or wrong, they knew he meant it. SATURN went to NASA anyhow.

It was only a matter of time until NOVA (later rechristened SATURN) triumphed over the original SATURN IB at NASA and became the basic booster for the U.S. man-in-space program. Transferring the Von Braun team out of the Army helped cool the Army's ardor for a major missile and space role and relieved its R&D budget of that burden. Transferring the big booster function to NASA similarly helped tone down military interest in futuristic space missions. Johnson, having experienced the persistence and power of the Service bureaucracies and their supports, later told the Congress that he particularly opposed the SATURN transfer to NASA because he feared that Air Force would turn around and develop one of its own, at immense cost, and the country would be stuck with two super booster programs:[99]

> The concern I have had about transferring SATURN to NASA was that by so doing, since the Air Force has now been given primary military responsibility for space programs, that the Air Force

> would then begin to create its own system, including its own booster, and it is possible -- unless you gentlemen watch this very closely -- that we will be going down the road of developing another multi-billion space system to put Dynasoar into orbit -- to do many other things -- and the military will not use the SATURN project, and we will have two parallel programs.

York's gamble again proved correct because the Air Force, despite some determined efforts, was never able to transform Dyna-Soar into a major program effort and found that NASA was particularly reliant upon it in the booster area anyway.

Former ARPA staff recall Johnson's SATURN battles vividly and with admiration. At the time, virtually all of them felt he was right and they were fiercely proud of his willingness to dispute York, Quarles, Killian, NASA, BOB, and the Administration. After his resignation, he returned to do battle on Capital Hill. With the wraps off, he railed against indecision in the space program and once again pleaded for maximum support:[100]

> Finally, I would suggest that this committee continue to be the watchdogs over the SATURN space vehicle. This continues to be our big and by far the most important space program for the defense of our country. It will give us the potential to meet Russia in space weapons delivery. Anthing more I would say on this matter is classified, but I plead with all my heart and head that you not permit this SATURN vehicle to lag for the want of money, management, direction, or military support.

Even though he was wrong about the specifics -- the SATURN IB and a direct military role in space -- his supporters feel that the subsequent Kennedy-Johnson decision to spend billions to go to the moon was in many respects a vindication of his vision.

Throughout much of 1959 a parallel struggle ensued over transfer of the high energy CENTAUR upper stage to NASA. Quarles and York had a much more difficult time bringing themselves to part with it because its use with military payloads was certain and they were reluctant to run the risk of undue disruption. This transfer finally did go through, however, and ARPA's connection with space launch vehicles ceased.

<u>The Maneuverable, Recoverable Space Vehicle (MRS-V)</u>. The MRS-V program never reached formal status in the ARPA budget beyond the study stage, but Godel and Clark have confirmed that as the thinking of Johnson

and his associates (excluding York) matured, this concept became central to the ARPA view of the future. Despite the Buck Rogers connotations, ARPA's reference point actually was concern for practical considerations. It was assumed that if space vehicles were to be useful to the military in the long-run, they would have to be maneuverable (flexible) and recoverable (economic), or as Johnson and Clark concluded, "You can't say you've conquered space until you can go in and out at will."[101] Roy Johnson certainly convinced himself that MRS-V had utility. He also felt that he had a good eye for determining what would "sell" and MIS plus MRS-V was his selection. MRS-V subsumed the super thrust booster and man-in-space. ARPA used to call NASA's Project Mercury the "first phase" of manned space flight, implying that there would be other phases which the military might wish to carry further, for its purposes, then would the science agency. ARPA fought for SATURN and a DOD role in development of large launch vehicles largely because it wanted to be in a position to achieve a MRS-V type capability. Johnson explained the military interest in SATURN to Glennan in September 1958: "The early capability afforded by the cluster project would make possible a space platform for manned reconnaissance and for a related military space operating base."[102] NASA's NOVA would phase in after SATURN and be used to support later military missions. ARPA never opposed NOVA and in fact offered to add funds to it when the project was under Air Force sponsorship and later volunteered funds to start work on a NOVA test stand at a time when NASA was having initial authorization and budget difficulties. While NASA concentrated on capsule recovery, DOD would look beyond to maneuverable and recoverable vehicles which would "most nearly satisfy the military objectives in regard to flexibility of mission and independence from ground guidance and recovery operations during hostilities:"[103] The strongest case for MRS-V was stated by Johnson in these terms:[104]

> ... This program, as currently envisioned by ARPA, will go beyond the NASA man-in-space program which has the goal of putting a manned capsule into orbit then effecting a recovery after descent by parachute or other retarding device. The ARPA viewpoint is that if a manned orbital vehicle is to avail itself of its military potentialities it must be capable of maneuvering in and out of orbit and of being under sufficient piloted control to operate from predetermined fixed military bases. This, of course, will involve take-offs and landings. Maneuverability is of prime importance in evading interception and minimizing susceptibility to countermeasure and destruction of a manned satellite.

It should be noted that Johnson was being advised by the IDA technical staff that NASA was not doing the "human factors" R&D that was necessary to support the mating of man with the MRS-V concept.[105]

Although the phrase MRS-V implied a specific system or vehicle, ARPA called it a program or "broad technical area" investigation that hopefully would lead to a system. The initial studies were intended to analyze possible "mission concepts" and to commence preliminary consideration of subsystems and components that might be needed. It was assumed that data from the X-15, DYNA-SOAR, and Mercury programs would be fed into MRS-V and that gradually a maneuverable, recoverable technology would grow to the point where specific system would emerge. IDA proposed including an analysis of the capabilities, advantages and disadvantages of using man in the program in recognition of the fact that this crucial issue was not fully resolved.[106] Compared with Roy Johnson's provocative language, ARPA's explanation of the aim of the FY 1960 MRS-V program was decidedly temperate: "The goal for the year is to create an unprejudiced and knowledgeable climate from which rationally justified military systems and research may evolve."[107] The JCS weighed in with a formal endorsement of the concept. The latter-day NASA interests in space platforms and recoverable boosters make these ARPA ideas look considerably less far-fetched than they seemed to detractors in 1958-59, though without the military connotation. On the other hand, events have shown that they were not "needed" either to match the Soviets or to fulfill urgent security functions on the time schedule which so completely dominated Johnson's words and actions. Sensitive to costs, Johnson estimated in 1960 that maneuverable, recoverable space vehicles for strategic purposes and an effective BMD system alone could consume the entire defense budget.[108] He felt that money was being squandered and priorities were not being set properly. Achievement of the manned, recoverable capability (starting with a SATURN booster) was his number one priority. When York moved to exclude ARPA from space activities, Johnson's hopes were reduced to Air Force continuation of DYNA-SOAR. Using his authority as DDR&E, York was able to cut the project back in 1960 (it was cancelled outright in 1963), in the face of immense cost increases and gradual acceptance of the view that man in fact was not essential to military space functions:[109]

> All of the rationalizations that were based on having the man perform some specific military function were found to be faulty. Either the function could be better performed within the atmosphere than above it or it could be better performed by an unmanned satellite than by a manned one. The general rationalization that man was more "flexible" was, of course, true, but its relevance to the Air Force's mission was never clearly established. Furthermore, saying that a man's judgment is necessary somewhere in a military space system is not tantamount to saying he is needed in the part of the system that actually orbits.

The Transfer Issue

Despite the often deep distrust between ARPA and the Services and ARPA and the PSAC-types, ARPA was unusally non-acquisitive or possessive for an agency of its size, budget and stature. Roy Johnson and all his senior aides believed in rapid transfer of satellite programs to the Services for operational deployment, as soon as feasibility was proven. Repeated interviews reveal that the ARPA staff reflected almost perfectly the feeling of the times that there were countless important scientific and technological jobs to be done. They did not feel particularly proprietary about keeping projects. As early as July 1958 Johnson specifically asked the Secretary to designate an operating agency for the reconnaissance satellite system.[110] He felt then that it would be cost effective to make such a designation so that training programs, hardware and facilities scheduling, etc. could be phased in and because it became obvious that the R&D on ground communications and data processing could be done in the same facilities that would be used for the operational system. Johnson annoyed the Air Force, of course, by suggesting that the Secretary consider a joint interservice command reporting to the JCS, to operate the system.

In the spring of 1959 ARPA formally recommended that the Secretary and the JCS designate operational responsibility within the Services for the reconnaissance, missile warning and navigation satellites and the satellite detection programs so that they, as the ultimate users, could make preparations to receive these interim systems and continue their development.[111] Roy Johnson determined as a matter of policy that ARPA responsibility for space programs normally should terminate with the successful performance of a first prototype model. "Termination" was by now foreseeable. By mid-1959 ARPA had estimated actual transfer dates for the reconnaissance, communications, navigation, and missile early warning satellites and the satellite detection fence, all falling in the 1961-62 period.[112] The bulk of ARPA's planned space program thereafter was to rest with achieving flexible manned space mission capabilities. In early September Johnson formally requested that the Secretary transfer SAMOS, TRANSIT, COURIER, SATURN, and SHEPHERD (tracking) space system development projects to the designated Services.[113] On September 18, 1959, the Secretary formally assigned responsibility for payload development and payload R&D support and production improvement for the interim satellite early warning and reconnaissance systems to the Air Force, the interim navigation system to the Navy, and the interim communications system to the Army.[114] Air Force was made responsible for all DOD launch vehicle interests.

In theory, Johnson foresaw ARPA continuing to do advanced space research, primarily oriented to maneuverable manned operations. Events were to snuff out that vision before the end of 1959. Thus ARPA merely had been, in effect, a "holding company" for the space program:[115]

"Yes, strictly, that's all it was ... until the decision was made to set up NASA. It was strictly a holding operation."

THE PROGRAM BASE FOR THE 1960'S

Although Roy Johnson devoted most of his time to the space program and bitter disputes over power and policy, there were other important activities under way in the Agency. Programs in ballistic missile defense (BMD), solid propellant chemistry, and materials science research were formulated during Johnson's tenure and the nuclear test detection research assignment was formally made, though not yet publicly announced. These programs were to form the core of ARPA's substantive interest for a decade. Thus the experience of rapid program spin-offs following the first two years of ARPA's existence was followed by a lengthy period of programmatic stability.

Ballistic Missile Defense

As noted in Chapter I , the subject of defense against missiles was raised by some scientists and others in the mid-1950's. Considered far-fetched at first, Soviet ICMB achievements suddenly gave the subject credibility and urgency. The President was forced to concede after Sputnik that "no defensive system today can possible be air-tight in preventing all break-throughs of planes and weapons" and he admitted the need to develop an active defense against missiles.[116] Killian had been prominent in warning that the U.S. was vulnerable to the missile and it was no surprise to find that research and development on BMD systems was formally listed as a highest priority objective by the President in January 1958, along with the IRBM's, ICMB's and military space programs.

Air Force and Army were developing competing systems, WIZARD and NIKE-ZEUS, respectively, at the $40 million per year level. McElroy was generally supportive of the Army role in BMD, but genuinely fearful that he could not keep the Air Force out. The two Services had been battling for the future operational mission assignment by conducting R&D programs as "natural" extensions of their respective interests in air defense.

The incentives, in this sort of environment, tend to lie in the direction of a premature rush to get something operational at the expense of an optimal R&D program. Late in 1956 Secretary Wilson sought to reduce the friction by assigning Army responsibility for point defense against ballistic missiles and the Air Force responsibility for area defense, with both programs to be monitored by a DOD ABM Committee.[117] In January 1958, McElroy ordered continued development of NIKE-ZEUS and a halt to the WIZARD program. This decision applied to system development only; assignment of the future mission responsibility for deployment was not addressed. McElroy was aware that part of Gen. Schriever's attack on Eisenhower's State of the Union Message endorsement of ARPA was based on anger over the Air Force's potential exclusion from BMD work.[118] He also knew that the Air Force was keen on concepts such as BAMBI (Ballistic Missile Boost Intercept) and SPAD (Space Patrol Air Defense) using satellite-based interceptors. He had visions of an immensely expensive program based on this notion, over which he would have no control, not to mention serving as a platform from which the Air Force would mount an unrelenting political attack on ZEUS and anything else the Army proposed to do. Thus ARPA was assigned all BMD work in DOD primarily as a means of excluding the Air Force from this field.[119] By putting it there, McElroy also hoped to get an objective assessment of future alternatives -- on that criterion ARPA performed well because it did not endorse satellite-based systems and it played a major role in the downfall of ZEUS as well. From the very beginning of his conceptualization of an ARPA, McElroy lumped BMD with space R&D as a major assignment. Thus a problem area with Presidentially-approved priority was selected in advance for the advanced research group.

At the technical level, a number of scientists had become interested seriously in BMD problems. William Bradley had directed a subcommittee of the Gaither Committee in 1956 that looked into the problem of identifying re-entry bodies (Albert Latter and Richard Holbrook of RAND and William Hutchins were among its members).[120] Holbrook, in fact, had been working on BMD systems problems since 1953. Bradley's Gaither Subcommittee thought that the main problem was kill mechanisms and discussed the feasibility of decoys, jammers, etc. that would complicate the "kill" task. They looked at all the known discrimination measures, producing relatively arcane technical analyses that were, of necessity, linear, i.e., extrapolating from one event to many but with no ability to handle interactions. They recommended an elaborate research program, but had no idea how to start it.

This group felt that the decision to proceed with the Vanguard program probably would lead to a new, temporary space agency somewhere in DOD. It believed that the BMD problem was also well-suited to such an agency: it was tri-Service; it would be very expensive; and the subcommittee and the scientific community were already convinced that ZEUS would not work, though none were under the illusion that the Army could be "turned off."[121]

About a month after Sputnik, Holaday set up a Reentry Body Identification Group under Bradley with the task of advising offensive missile designers whether the Soviets could successfully build an anti-missile defense system.[122] Most of the members had been on Bradley's earlier group:[123]

> They studied the question of whether ABM was possible.... They studied both sides of that question, and they talked about penetrating ABM's, and they talked about multiple reentry vehicles as sort of being the ultimate penetrator....

They considered virtually every kind of potential decoy: booster fragments, chaff, radar blackouts, etc. Multiple warheads were postulated as a means of simply exhausting or saturating the defense.

Bradley's group was at work in November 1957, during the period when McElroy was formulating SPA and ARPA. Holbrook believes that somebody on the technical side appealed to the Secretary and/or Quarles to include BMD in the new Agency's assignments and to give it all the Service funding for that purpose. In any event ARPA received the assignment, including all of the ZEUS program. Bradley meanwhile assumed chairmanship of PSAC's AICBM Panel, a group that included Harold Brown, Richard Latter, Wolfgang Panofsky, Edward W. Purcell, and Jerome B. Wiesner. Presciently, this Panel reported to Killian in April that the BMD problem was immense:[124]

> Though we believe it is important for work in this field to proceed with the highest urgency, we also feel that it is important for you and others in key government positions to realize fully the extremely difficult nature of the anti-ballistic missile defense task and to understand clearly that there are many reasons to question the ultimate utility of such systems.

The Panel outlined some reasons for its pessimism -- kill problems, decoys, radar camouflage, electronic countermeasures -- and urged a comprehensive R&D program to investigate them. Existing fragmented programs would not suffice and neither would ARPA because its range of responsibilities was so broad that ABM work would get lost in the shuffle.* The Panel feared that: (1) DOD was in danger of developing at least two independent and incompatible BMD systems, and (2) many of the most difficult questions would "continue to be ignored or swept under the rug." Accordingly it recommended a special agency with the following tasks:

1. Establish immediately the characteristics of the NIKE-ZEUS as a completely integrated system, given certain

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* This fear may have been well-founded until ARPA lost the space programs and DEFENDER became its largest effort. The project was thoroughly reorganized following the transfers.

doubts about the concept the Army had under development.

2. Establish a system for realistically testing the effectiveness and operational readiness of an ABM system.

3. Establish an effective research program on warhead and re-entry body destruction.

4. Establish a research program on methods for coping with decoys and jamming.

5. Sponsor an intensive component and sub-system program.

6. Decide on the development and testing of the interim system.

7. Integrate the BMD system with the continental defense system.

8. "Search for and give support and encouragement to needed new ideas in the field. Proposed systems may very well not work."

9. Continue to examine and evaluate evolving systems ideas in the light of new scientific information.

10. Inter-relate the ICBM and AICBM work.

Removing the few near-term and more operationally-related tasks on the list (which ODDR&E ultimately was to take on) it was a classic definition of an ARPA assignment. DOD did not accept the suggestion to create another new agency, but ARPA undertook and developed the mission from almost exactly the viewpoint outlined by Bradley's Panel. While working with PSAC, Johnson and York also sought Bradley's advice, including his assessment of work being done around the country in the BMD field.[125] Bradley later directed the IDA work program for ARPA. The first two ARPD/IDA staff hired for BMD work were Hutchins and Holbrook. ARPA also attracted first quality talent by means of ad hoc panels, committees and review boards. For instance, Drs. F. J. Overhage (Lincoln Laboratory), Sidney Passman (RAND), Edward M. Purcell (Harvard), Chalmers Sherwin (Illinois), and Jerome Wiesner (MIT) were established as a review board to determine the extent to which the technological feasibility of infra-red satellite systems for ballistic missile defense had been demonstrated by available evidence.* The board's views definitely influenced ARPA's funding decisions in this area. ARPA thus became the focal point for the work of a cadre of highly imaginative scientists whose work was to have immense impact on ballistic missile defense in the United States. Moving easily between ARPA, IDA and other not-for-profits, industry, PSAC panels, and other advisory groups, they were able to exert great influence. York is highly complimentary in this regard:[126]

> [S]o you've got a flow of guys with particular memories through all this sort of thing and part of what ARPA has contributed over the years is to have been a focus of these people; it's been a part of the intellectual idea exchange mechanism at the very top of the Defense Department. That probably has worked quite a bit better than it would have worked if it had been in a Service.

One of the biggest tasks awaiting Roy Johnson on his arrival was how to manage the very large existing BMD programs inherited from the Services and how to create an "advanced" research effort seeking to go beyond them. He very quickly concluded that ZEUS was much too far along in the development cycle to warrant ARPA involvement. Much of the money requested for ZEUS in FY 1959 was for early commitment of pre-production, production and construction funding. Johnson was a sufficiently experienced businessman to recognize the pitfalls of trying to direct an operational systems program from an R&D unit. In his first Congressional presentation of the ARPA program he said that "we did not feel that ARPA should ever get into that kind of a program where hardware [procurement] was contemplated. ARPA's role is to stay with research out ahead."[127] Thus he sought and obtained McElroy's approval to return ZEUS responsibility to the Army. ARPA's role was described as "general direction of developmental efforts for an active missile defense system against the ICBM" and the ZEUS money in ARPA's FY 1959 budget ($57.7 million) was simply transferred direct to Army.[128] The following year ARPA was out of that channel completely. Meanwhile it sifted through USAF-supported work in radars and systems concepts such as BAMBI and SPAD, accepting some and modifying, dropping or phasing out the rest. One of York's first acts as DDR&E was to formalize this arrangement by assigning responsibility for BMEWS to the Air Force, for the ZEUS system then under contract to Western Electric to the Army, and for "research in the

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* The same technique was used successfully in the space programs, e.g., an Ad Hoc Panel on Communications Satellites composed of Wiesner, John Pierce of Bell Telephone Laboratory, H. V. Gaskill of Collins Radio, and A. F. Donovan of STL.

field of Advanced Ballistic Missile Defense" to ARPA.[129]

The outlines of Project DEFENDER were sketched when Johnson and York testified on the first ARPA program in April 1958. Its purpose was to do research on unanswered BMD questions, leading to techniques and equipment that might up-grade the ZEUS system or lead to an entirely different one. Johnson and York conceded that ZEUS was the best thing available, but refused to be very positive about it. York stated, diplomatically:[130]

> There is no agreement on how effective NIKE-ZEUS will be. It will certainly work to some extent, but I do not know how well. I really cannot answer the question because it is the usual race between offensive and defense.

The as yet unformulated ARPA BMD program was outlined by York in a way that captivated his House Subcommittee audience. The building blocks of the program would be: (1) identification and study of relevant re-entry phenomena, (2) what to do about decoys and discriminating between them and the warhead, and (3) weapons effects. ARPA would consider not only re-entry problems, but detection at the launch period as well in order to get extra warning time:[131]

> [O]ne of the reasons for doing this research on finding out what happens as this nose cone traverses the atmosphere is to see if nature is not on our side, so to speak, and if we cannot discover some phenomena that we can use in order to detect it on its way up.

It was also pointed out that the data processing requirements implied by successful detection of and discrimination among reentry bodies would require the design of new computer systems. It is difficult to imagine in this day of desk-top computers, but in 1958 York was compelled to explain what a computer was:[132]

> ... One of the next things we have to try to do is to design a computer system which is a big set of electronic hardware that does mathematics at a faster rate than it can be done any other way. We have to design some kind of a system that will notice that some of these are slowing down faster than others and automatically tell us that they are not the warhead. That means that there has to be designed a big piece of what is referred to as a logical machinery. In principle, if you have all of this data, afterward, in the next couple of weeks, you could look it over

> and decide which is what, but all of it has to be done in that one minute, and no human reaction could be fast enough. All of this has to be done by a machine which is designed, not only to observe these things and observe all of the tracks that they are making, and so on, but a machine which can actually decide that some of them are going too slow and are not the warhead, and, therefore, shoot at this other one over here.

One of the first moves Johnson and York made was a visit to Lincoln Laboratory (May 13, 1958) to encourage Lincoln to expand its field measurements of radar echos from reentry bodies, at various frequencies. Johnson at one time was thinking of a Ramo-Wooldridge type of management structure for all of DEFENDER and also broached this idea to Lincoln. The latter, somewhat skeptical about Johnson's "fourth Service" line, felt that DEFENDER was a chancy program and decided that there was some danger in getting too locked into it.[133] Lincoln did agree to gather basic physical data under an ARPA Order with an effective contract date of October 1, 1958 and it also left the door open to expansion:[134]

> Later, if warranted, it is expected that further experiments will be included to investigate methods for applying the knowledge gained to the problem of ICBM decoy discrimination or reentry body discrimination....

Thus the groundwork was laid for a partnership, often somewhat petulant, that became a mainstay of future ARPA programs.

When Hutchins, Holbrook and the other IDA staff began to assemble in ARPA in June and July 1958 they were confronted with a $110 million budget. Knowing that the IDA BMD group was planned to be eleven men, they divided the $110 million by eleven and developed an eleven part program outline in a matter of a few days. This soon evolved into a "panel" structure, but with each panel essentially consisting of a single "chairman" drawn from the group. With Hutchins serving as overall group leader, the first framework consisted of panels for: upper atmospheric physics, very early warning, instrumentation and special ranges, destruction mechanisms, anti-satellite defense, active defense, interception, data processing, and radar.* Obviously, an equal division

* To give the flavor of the IDA arrangement, each "panel chairman" was drawn from a different defense contractor group. The contractor affiliations of each of the above panel heads were, respectively: Sylvania, RCA, Lincoln Laboratories, Ramo-Woolridge, Bell Telephone, RAND, JPL, Sandia, and General Electric.

of budget between these panels was not particularly logical, and some of the technical areas (e.g., radar) grew quite large while others were modestly funded, and eventually merged into broader organization categories. Nevertheless, the tendency to more or less evenly divide the work between strong, co-equal staff members resulted in a rather sprawling DEFENDER organization throughout the Johnson period. This was a condition that was to be criticized and rectified during J. P. Ruina's tenure.

Simultaneously with attempting to structure a program, it was necessary to deal with industry proposals. ARPA assumed that industry would be the most likely source of ideas and for most of 1958 the BMD group was deluged with them. As with outer space, the pace was frantic. It was not unusual to schedule seven or eight presentations a day. The scramble for contracts was intense. For instance, one participant recalls getting three different proposals for acquisition radars from three different parts of Raytheon, each of which did not know about the others.

As with the outer space projects, BMD work had its moments of melodrama, or so they seem in 1975. ARPA considered the Tradex, Pincushion, Arecibo, DAMP, and HF Ionospheric radars to be a set which hopefully would produce high quality and hitherto unavailable data about warhead and decoy flight before and during reentry. Far from being regarded as routine developments these radar programs were considered by ARPA to have truly revolutionary implications. A contemporary description of the radar program tells us something of the tenor of the times and of ARPA's visualization of its own role:[135]

> The high state of development of radars placed it in the forefront of sensor technologies applicable to BMD systems. The state-of-the-art at the inception of the DEFENDER program appeared to be not too far behind the requirements to meet the earlier postulations of the BM threat. It was soon apparent, however, that nose cones of more sophisticated design accompanied by even the crudest decoys placed BMD radar requirements at best several orders of magnitude in advance of the capabilities of the most advanced existing air defense radars. The most serious deficiencies existed in the high power, resolution, and multiple target handling capabilities. <u>The scope of these deficiencies dictated the need for heroic measures</u>; and accordingly, the early DEFENDER program spawned some entirely new concepts in radar design; i.e., ESAR, PINCUSHION, ORDIR, etc. (Underline added.)

In the same vein, ARPA launched GLIPAR, the Guide Line Identification Program for Anti-Missile Research. This was a somewhat innovative management approach intended to identify unorthodox approaches to the BMD problem. The program itself, the way in which it was handled and the use to which the results were put were somewhat characteristic of the free-wheeling ARPA of 1958-59. First, the philosophy behind GLIPAR:[136]

> Project GLIPAR may be viewed as an experiment in research methodology. It is likely that unexpected benefits will accrue, but there is no assurance that its directed goal will be achieved, that of setting an effective stage for rapid development of vast new capabilities in defenses against ballistic missiles. If the project is to have reasonable chances for success at all, it is necessary that the broadest possible attack be made; this imples a large number of independent efforts. The requirement for wide diversity derives from the fact that one cannot predict in advance where the critical contributions will be made. Hence, the best that can be done is to arrange for a wide array of independent and competent thought to be focused upon the problem at hand. (Underline in original.)

Second, the participants were given a set of parameters quite unlike those conventionally issued: (1) to examine possibilities on a very long time scale, namely, 20 years ahead rather than "immediately," (2) the necessity to prove the non-feasibility of an idea; that is, ideas were to be taken as plausible unless it could be demonstrated that they were not feasible, and (3) each response was to contain a package of alternative solutions with relative values placed on each alternative, rather than dealing exclusively with a single approach.

Third, the program was developed and carried out with remarkable speed. Internal discussions were begun in early November 1958. By January 30, 1959 Roy Johnson had invited 48 organizations to attend a bidders' conference. Forty-two of them attended the conference in February and 30 submitted proposals by March 20, 1959. An advisory committee of two principals and one alternate from each of the Services was used to compare and rate the proposals. IDA staff did not participate in the voting but did take part in the committee's deliberations. ARPD/IDA used the committee's work as a basis for recommendations to ARPA in April, namely, the funding of 12 contracts at an average cost $135,000 each: Aeroneutronics, Allied Research, University of Chicago, Convair, GE Tempo, General Mills, Hughes Aircraft, Industrial Research Associates, Ramo-Wooldridge, RCA, Republic Aviation, and Technical Operations, Inc. Each contractor was given seven months to write his report. Then all of them spent two months working together to integrate their findings, joined by well-known consultants and DOD personnel in order to give the final product appropriate exposure and "national recognition." Speedy decision-making, use of many firms and universities, and the involvement of Service and IDA technical personnel were common in ARPA. Later the Agency was to become more self-oriented, but it still retained a penchant for drawing on outside talent. ARPA's willingness to involve Service R&D people in its work, even at the program planning stage, e.g., GLIPAR, Solid Propellant Chemistry and the Materials Sciences, was an important factor in breaking down initial Service hostility to the ARPA idea and it helped smooth establishment of the executive agent system on which ARPA had to depend for procurement and detailed technical monitorship.

Illustrative of ARPA's high risk outlook, the Agency commenced support of laser work in 1958. Dr. L. Goldmuntz, then associated with a small firm (TRG) that had an idea about the laser concept, relates that he had knocked on just about every door in Washington before someone suggested trying ARPA. There he recalls finding people: (1) willing to listen, (2) able to understand clearly what was being said, technically, and (3) in a position to act.[137] ARPA provided support for the idea. Indeed Dr. Charles Townes credits ARPA with being the first to support a major effort in laser development:[138]

> ARPA did it before it paid off in any military sense -- that's their function. So their early work was quite important.... Though ultimately TRG did not contribute anything spectacular, ARPA helped to get the field going.

Compared to the space programs, ARPA's BMD work tended to draw favorable, if exaggerated, media coverage:[139]

> <u>DEFENDER</u> ... is of such fantastically increasing complexity that it makes such medieval problems as counting angels on the heads of pins appear easy by contrast. It involves study of such possibilities as death rays, anti-gravity machines and magnetic walls.
>
> The glittering goal of the entire effort is the development of an ICBM defense that would be both much better and much cheaper than than the Army's NIKE-ZEUS....

By mid-1959 ARPA had identified what was to become the crux of the great ballistic missile defense policy debate a decade later:[140] "Money is very important in all this. We want something that costs us no more to use against an ICBM than it cost the enemy to launch the ICBM against us.

Otherwise, if it costs us a million every time he spends $100, he'll ruin us."

Solid Propellant Chemistry

Solid rocket propellants had been identified by scientists in the mid-1950's as worthy of special research attention. The von Neumann Committee urged an accelerated program and when PSAC was set-up, Dr. George Kistiakowsky put together a panel to review the status of solid propellant chemistry and prospects for improvement. He reported to Killian on March 13, 1958.[141] The verdict: entirely inadequate R&D effort in a field which could be regarded as "wide open." Kistiakowsky's panel recommended a vigorous R&D program featuring the following characteristics: central coordination and direction; information exchange among participating organizations; a level of effort in the range of support for 50-100 Ph.D. chemists; strengthening and using existing organizations (Aerojet, Thiokol, Rohm & Haas, Redstone, and JPL) for applied research; support of work on synthetics with research teams at large chemical firms such as DuPont, Carbide, MMM, Olin-Mathieson, etc.; and support of university scientists to work on synthetics and the thermodynamic properties of materials under consideration.

The panel was somewhat appalled at the small number of Ph.D. level scientists at work on solids (no firm had more than nine; most had one or two) and felt that this fact alone could explain much of the slow rate of past progress and "the lack of obvious prospects for dramatic improvements in the near future." The panel argued that throwing advanced propellant problems at "high powered research groups containing dozens of Ph.D.'s of high caliber should provide a variety of compounds within a short time (12-24 months), or prove that efforts in these directions are nearly futile.[142] This work was to be undertaken with urgency.

Prior to submitting his report to Killian, Kistiakowsky and Lauritsen of PSAC met with Holaday and Betts to urge the importance of establishing a DOD program. On that occasion Kistiakowsky suggested that ARPA should have the program and that John Kincaid on the ARPD/IDA staff should direct it. More formally, Killian, Kistiakowsky, York, and Holaday discussed the report and Killian sent it to McElroy on March 18. A note on Killian's letter in what appears to be the Secretary's handwriting reads: "Should we definitely assign a basic program on solid propellants to ARPA -- for all Services?"[143] (Underline in original.) Thus even before Johnson and York were on the job full time, the groundwork was laid for another major assignment; however, Quarles and Johnson decided first to do a survey of solid propellant R&D in DOD before committing to the project.[144]

On June 7, 1958 Quarles assigned ARPA "the project of advanced research in the field of high performance solid propellants including the supporting research necessary to permit effective use of these new high-energy materials when they become necessary."[145] The objectives of the program (PRINCIPIA) were defined as follows:

> Under this directive it is expected that the Advanced Research Projects Agency will set up research programs intended to make available for developmental applications, solid propellants having specific impulses at least 10-20% higher than other propellants now under development for operational application. The supporting effort shall include research on inspection methods, unstable burning and deflagration-detonation transition. Also, because of the very high flame temperature associated with high energy propellants, the supporting effort shall include research on methods of cooling, thermal-insulation and heat resistant materials. The program is expected to lead to new materials and new principles which will be utilized in future missiles and rockets. The development of end items shall not be undertaken under this directive.

The shape of the program needed to achieve these objectives was left to ARPA. ARPA was also instructed to cooperate closely with the Services and use their contractual and technical administration capabilities as much as possible. This language served two purposes: (a) to pacify those in the Services who feared a totally independent or "closed" ARPA, and (b) to make it clear to scoffers that the Secretary expected the Services to make their organizations available.

John Kincaid of ARPD/IDA developed a program strategy and the three Services were requested to play an active role, particularly in soliciting industry for ideas and in evaluating them technically.[146] This was a pattern ARPA was to follow often and was content to use, provided the Services did a quality job. In addition to industrial firms, the universities, not-for-profit and in-house DOD organizations were also to be tapped. The primary goal of the program was to discover new chemicals, devise practical ways of synthesizing them, and develop enough knowledge to use them in highly efficient solid propellants. The initial target of the program was a solid propellant with a specific impulse of at least 280 seconds at a chamber pressure of 1000 psi, discharging to the atmosphere at sea level.[147] Roy Johnson sent letters to 39 large firms in June, inviting them to a July bidders conference. ARPA moved ahead very quickly, attacking this assignment with the same zeal as was being shown in the space and BMD programs.

One major component of the program was based on the "integrated contract" concept.[148] Certain contractors were selected to do thermochemistry, thermodynamics and performance estimates, chemical studies to synthesize new ingredients, propellant formulation and preparation, and static testing of the resultant propellant in the range of 10 lb. grain size. Apparently it was unusual to try to have one contractor perform all of these types of research on a consolidated basis. Expectations were high: "the new ingredients which are expected to become available under each of the integrated contracts are likely to leave properties quite different from those now used. Therefore, novel and ingenious approaches are called for in order to formulate and test these new propellants." ARPA was prepared to fund the construction of such facilities. Minnesota Mining and Manufacturing, American Cyanimid, Dow and Esso were selected.

A second component was organized around "propellant performance contracts" designed to select and assemble "best thermodynamic values, performance calculations based upon these values, and kinetic studies aimed at the elucidation of processes involving performance which occur during expansion." These studies were intended to provide a basis for the selection of those areas in chemistry where progress was most likely to occur. Government, private and university laboratories were involved. A third block of contracts was concerned directly with development of specialized synthetics, using laboratories with particular competencies. Again, a wide variety of sources was tapped.

The three Services were given \$750,000 (divided equally) to explore the use of new chemical ingredients as propellants in in-house laboratories. This step was taken allegedly to insure that compositions involving new ingredients did not become proprietary. In addition, contracts were awarded to industry and universities for work in high temperature problems and some basic research. Following is a brief summary of the first year's program allocations (FY 1959):

Integrated Contracts	\$6,200,000
Propellant Performance Contracts	2,000,000
Specialized Synthetic Contracts	4,000,000
Propellant Research Contracts	850,000
High-Temperature Contracts	650,000
Basic & Miscellaneous Contracts	1,300,000
TOTAL	\$15,000,000

Over 50 contracts were let and the roster of recipients represented virtually every important source in the country, including some universities (Ohio State, University of California, Penn State, Duke, NYU, Florida, Brooklyn Poly, Princeton, Texas, and Vanderbilt).

By all accounts, ARPA had established a sound applied research program in propellant chemistry that hopefully would contribute to future missile systems. If it had a flaw, it was that the expansion of work in this area presumed either that unemployed resources existed or would be diverted from lesser priority projects. Kistiakowsky's Panel put the emphasis on urgency, however, so that risk was accepted.

Materials Sciences

ARPA's Materials Sciences charter has a professional and bureaucratic pedigree at least as long as the Propellant Chemistry assignment. In the post-World War II period a number of materials advisory committees had sprung up under DOD, AEC, National Academy and other auspices. This subject was often singled out by Killian and others in the mid-1950's as a priority item for increased attention. By common consent, "materials" seemed to be the single most important limiting factor on progress in military, space and nuclear systems development. At the same time prestigious voices were raised in support of doing materials research in interdisciplinary laboratories (IDL's). John von Neumann, for instance, became an ardent and influential supporter of this idea.[149] An ONR-sponsored panel on solid state science in 1956-57 expressed concern about inadequate basic research and training of people to do it. A National Academy of Sciences panel conducted a study for the Air Force in 1957-58 which recommended -- without immediate effect -- the establishment of a national materials laboratory.

Despite the growing awareness in the late 1950's of problems in fields related to materials sciences, it seems doubtful that a major national program would have been established had it not been for the spectacular intervention of Sputnik. According to Sproull, the National Academy of Sciences study proposal had been viewed widely as a threat by universities, industry and government alike -- largely because a national materials laboratory might be too powerful a competitor for scarce scientific talent. Sputnik, as it did in many other fields, immediately changed the picture. The Assistant Secretary of Defense for Research & Engineering identified basic research to discover "new concepts of materials" as "the most important field today in research. We need breakthroughs in all the fields of materials."[150] DOD augmented its FY 1958 budget for basic and supporting research in materials with $55 million in Emergency Funds, a 40 per cent increase.

Killian says that the impetus for the ARPA program came from William Baker of Bell Telephone Laboratory, who was a member of PSAC.[151] Baker chaired a PSAC Panel that concluded materials research was lagging badly. He then appealed to the Federal Council on Science and Technology to organize Federal agencies in a coordinated attack on the problem. The priority accorded this subject may be inferred from the fact that, according to Killian, it was the first program initiated by the Federal Council.[152]

The FCST in turn established a Coordinating Committee on Materials Science Research and Development to make detailed program recommendations. Chaired by Dr. D. K. Stevans of AEC, the Committee included representatives from BOB, Interior, NASA, NSF, NBS, and ODDR&E and used Baker of PSAC, Harvey Brooks and John Gison from Killian's office, and J. F. Kincaid, of ARPD/IDA as consultants. Kincaid and ODDR&E personnel undertook field visits and analysis in support of the Committee's work and to develop ideas for a possible ARPA program.[153] York, now the DDR&E, was a strong advocate of the IDL approach, having been influenced by von Neumann's earlier support for the concept, so DOD participation was enthusiastic.[154]

As for selecting ARPA as the locale for the program, York said that while possibly the Services could have done it, he knew ARPA would do it:[155]

> There is just less argument with ARPA about getting something like that [Materials Sciences] going, and doing it, than there is with the Services. The Services, whenever the budgets get tight, they squeeze out those things which there is nobody in the Service with passion for. And the budgets always fluctuate; in fact fluctuate every year. They've submitted big ones, somebody cuts it back; it fluctuates while its still 'planning,' rather than money. Every time it fluctuates down, they take out the things that weren't invented by them. So getting something done in the Services is very hard for the Secretary of Defense and his staff.

As critical as York was of ARPA in late 1959, this rationale undoubtedly served as his principle reason for preserving ARPA as an institution.

The Coordinating Committee's findings were that a shortage of trained scientific personnel was a major limiting factor in the field; training of such people was a function of universities and they lacked the space and capacity to expand facilities appreciably; and agencies supporting basic research in materials were not underwriting adequate modernization of equipment and facilities. To overcome these deficiencies, the Committee recommended, among other things:[156] (1) Immediate allocation of funds for new equipment, (2) establishment of IDL's at universities to train more and better-qualified Ph.D.'s, and (3) long-term funding of basic research at the interdisciplinary laboratories. A program for shared sponsorship of a remedial program by the principal mission-oriented agencies was proposed, with responsibility to be shared on a 65% (DOD), 25% (AEC) and 10% (NASA) basis. Within DOD, York selected ARPA as the action agent. The official project assignment (PONTUS), dated June 8, 1959, read as follows:[157]

> The Advanced Research Projects Agency, on behalf of the Department of Defense, will undertake research, experimentation and development to obtain at the earliest practicable date a major improvement in structural and power conversion materials required to satisfy the military requirements of the several U.S. surface, air or missile programs. In the case of structural materials, this assignment shall include super strength materials, radiation resistant materials and materials intended for very high temperature service. In the field of power conversion, this assignment includes materials for thermoelectric devices and for electric and electronic circuitry capable of operation at high temperatures.

The "fine print" noted that a detailed work program would be developed in consonance with the national materials sciences program. Within two weeks York specified that the ARPA program would be the DOD portion of the FCST program.[158] He thought it of sufficient urgency to use DOD Emergency Funds to start the work. Killian says that PSAC strongly supported the ARPA program. Thus ARPA had another major assignment with definite White House antecedents.

Internally, reactions were mixed. It was recognized that a basic research program in the materials sciences was something quite different from managing space projects. As a practical matter, ARPA knew that it would "make the scientists happy."[159] Another point in its favor, from ARPA's standpoint, was that being primarily a vehicle for providing funds for institutions and facilities, it did not require a large staff. It was of interest technically because ARPA's exposure to space R&D had led to convictions that lighter weight, greater strength and lower cost materials were essential for space and other military systems. Col. Lay indicates that the Services were very keen on more materials science work, i.e., it was "relevant," yet it was clear that they lacked the competence to put together an IDL sort of program. "All of us thought a contribution could be made" and that the IDL approach "had a great future."[160] J. F. Kincaid (ARPD/IDA) was selected to establish and direct the program. Its cornerstones were immediate one-shot equipment grants, an intense competition to select candidates for IDL's, and development of three-year forward funding and means to facilitate the rapid write-off of new construction initiated by participating universities. The multi-year funding characteristic was to prove far more controversial than what the money actually was to be spent for. Remarkably little was said about the substantive research end products of the program beyond vague statements such as: "Ultimately this basic program is expected to make contributions to such important Department of Defense objectives as super-strength materials, radiation resistent materials, materials intended for very high temperature service and for thermoelectric devices."[161] In the heady atmosphere of 1958-59 virtually nobody questioned that there would be good results of relevance to military problems -- that was a foregone conclusion. DOD agencies were then pumping $70 million a year into material research. Indeed, it was assumed that a program designed to double the output of Ph.D. level gradutes and to establish large new interdisciplinary laboratories would automatically assist the DOD. ARPA assembled a Materials Advisory Group under Kincaid with Service and ODDR&E participants and it did much of the work leading to selection of universities both for equipment grants and for IDL programs.

Equipment Research Grants. The FCST estimated that $12 million worth of equipment, most of it "intermediate" equipment in the $25,000 class, was needed nationwide to modernize university laboratories.[164] DOD accepted responsibility for half of that amount, which ARPA funded in equal installments in the FY 1960 and FY 1961 budgets. ARPA used a team of experts from the military departments to compile a list of institutions and equipment needs. This ensured that the DOD contribution was invested at universities already engaged in DOD materials work, hence benefitting the Department, at least in theory. Sixty universities were considered and virtually all received the one-time grants. Some of ARPA's non-technical staff looked on this as the "pork barrel" segment of the program, that is, something for everybody. They were not convinced that the universities were in desperate need of the equipment or that it would directly assist DOD work. If it was needed, better that it be paid for as part of direct contract costs. The more cynically inclined saw it as a form of "rip-off," i.e., the "PSAC-types" passing out plums for their university friends and making DOD foot the bill. Nonetheless it was hoped that spreading this largesse around would temper political pressures to place the more lucrative IDL's in certain geographic locations.

The Interdisciplinary Laboratories. The IDL selection process was conducted with great care. Service experts and outside specialists* were consulted and a quite elaborate competition held. No undue political pressure was encountered in the early stages and this process had narrowed the field down from thirty to eight candidates by the time Roy Johnson departed in November 1959.[163] The controversy over the mechanics and philosophy of long-term funding lay ahead.

Another plank in the scientific community's program to stimulate basic research and to encourage excellence in American science was laid down. ARPA was to pursue it diligently for over a decade.

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* Consultants who played significant roles in the selection process were Drs. Morris, Tanenbaum, G. J. Dienes, M. E. Hebb, H. Holloman, and J. P. Howe.

ROY W. JOHNSON: THE CURTAIN FALLS

By the end of 1959, ARPA was effectively finished as a space agency. Roy Johnson also decided to leave, by most accounts a disillusioned man. 1959 had been a blockbuster. McElroy's departure was confirmed; Quarles died; York, a Johnson subordinate, was placed above him in the hierarchy; ARPA's role in Man-in-Space became completely marginal; the billion dollar budget had been destroyed; the military satellite payload programs were ordered transferred to the Services; Saturn was transferred to NASA; and any future ARPA space work was virtually foreclosed, particularly on anything as expansive as space platforms and MRS-V. The military payload, SATURN, and space exclusion decisions were made by York and sustained by his superiors. It had to have been a humiliating experience for the proud Johnson.

York had been appointed Director of Defense Research and Engineering in January 1959. One of his first undertakings was review of all the space work. He supported ARPA's proposal to transfer certain space payloads, but went beyond it to include all of ARPA's existing space programs and those that Roy Johnson deemed critical for the future, e.g., SATURN, MIS and MRS-V. Interestingly, Godel supported York's logic, which he has described as "military payloads belong in the Air Force and the rest of space is to be peaceful (NASA)," because it was sound OSD policy.[164] By this time Godel had concluded that: "A Secretary of Defense can direct, but he cannot do," i.e., he cannot, for long, substitute for the Services. He took the position that if the Services botched their space projects, the Secretary could always reassign them in ARPA. In any event, York's views on space project transfer were accomplished fact by the late autumn of 1959.

Johnson found York's elevation in the hierarchy hard to swallow. Although both testified on the Hill that there were no conflicts between them, personally or institutionally,* the "nice words," as York put it, "belied the real situation."[165] McElroy reaffirmed that Johnson reported to him, but there was no gainsaying the law which established the DDR&E as top man for Defense R&D. York in fact believes that Johnson left primarily because of the change in their relative status.[166]

In addition, a number of national figures were peppering the Agency with criticism and challenging its existence. For example, Gen. Schriever was again publicly proposing abolition of ARPA, albeit conceding that it

* DOD Directive 5105.15 was modified slightly on March 17, 1959. The Director of ARPA was still be appointed by the Secretary and the Agency was still to receive its assignments from the Secretary; however, ARPA's projects were soon made subject to "the supervision and coordination" of the DDR&E.

had performed a useful "interim function."[167] He argued that 80 per cent of ARPA's money was flowing through the Air Force anyway, so why not "bring the operator and the developer under the same tent." Dr. Clifford Furnas, Chancellor of the University of Buffalo and a former Asst. Secretary of Defense for Research & Engineering, urged that ARPA be absorbed within the new ODDR&E, and Senator Clair Engle proposed abolishing ARPA and moving all military space work to NASA.[168] ARPA had become a dartboard.

McElroy and Quarles also seemed to be weakening in their support. The Secretary of the Air Force led frontal assaults on ARPA at meetings of the Armed Forces Policy Council. On the defensive, McElroy told the Service Secretaries that he and York had reached an understanding that York would continue to use ARPA to conduct programs affecting the three Services that he felt warranted centralized management, in lieu of having ODDR&E do so itself. As one observer at a key AFPC meeting recorded it, McElroy said that "it was his intention to continue ARPA and that this fact should be accepted by all."[169] Quarles agreed with the Secretary, but indicated that "he was not sure that ARPA would have to be a permanent organization but that it was certainly required for the foreseeable future."[170] Killian claims that Quarles began to have doubts about Johnson and that by early 1959 "Quarles had no effective relations with Johnson and this made ARPA's problems difficult."[171] Godel confirms that Johnson and Quarles disagreed pointedly on the York appointment as DDR&E and on the value of SATURN. Apparently the only positive support for ARPA came from Admiral Arleigh Burke who remarked that the Agency was the only newly-created organization of its type he had ever seen that did not grow in size, out of control.[172] Nonetheless, a number of principals, e.g., Killian, York and Godel, independently confirm that Johnson gradually lost the confidence of McElroy and Quarles. When McElroy announced his departure, coming on the heels of Quarles' death, Johnson apparently was quite distressed. The new man, Gates, did not have the same feelings of paternity and close association that McElroy and Quarles had and there was no pre-existing bond of friendship either. ARPA's "disconnect" from the Secretary and the Deputy Secretary and loss of its original lofty status, formally heralded by creation of the DDR&E, was to be accelerated by these changes. Of course, Johnson certainly had no support at the White House. All this put added pressure on the new agency because the Services sensed it and raised the tempo of their opposition. ARPA's budget examiner at BOB also considered the Agency to be in serious difficulty:[173]

> In spite of the existence of ARPA and the DOD directive to the effect that that agency was to have the assignment of conducting projects dealing with military space technology, the 3 services have uniformly failed to inform ARPA of their sometimes substantial programs in this area to say nothing of

> coordinating them with the other services. As a result there has been no overall technical evaluation of the feasibility, priority, or relationship of the myriad military space projects. Air Force alone has a total dollar level of at least $78 million in FY 1960 programmed for military space technology ... there is now no present centralized technical control or cognizance of military space technology research and development projects.

The serious questioning of ARPA extended to the Agency itself. Some of the staff worried that the Agency might disappear and some thought it should be disbanded. Highly respected ARPA staff like Cols. Lay and Young, who were deeply committed to the importance of ARPA as the DOD space agency, felt that if its space role was to be terminated, the Agency should be closed down as well. At the York-Johnson press conference -- described as "argumentative" by the New York Times -- which announced the military space transfers from ARPA, and on other occasions, Johnson felt compelled to emphasize that McElroy had assured him that ARPA would be a permanent fixture in DOD.[174] York did not propose abolition but made no commitments about permanence, thus remaining consistent with the position taken when he first became the DDR&E: "At least for now ARPA remains.... It is always possible that these things will be changed. They will be resolved as we go along."[175] Signals from the White House, if there were any, were probably neutral. Killian has sketched the ambiance there as follows:[176]

> My recollection is that in the early days of its existence, most of us in the White House group viewed ARPA as likely to be ad hoc, but I think as its program developed under the leadership of Herbert York, our attitudes probably changed. Actually, I don't think there was any strong feeling either way.

IDA was particularly worried by McElroy's September 18, 1959 memorandum to the JCS that formalized transfer of the military space projects. Johnson chose to explain the situation to the President of IDA as follows: [177]

> Despite some press reports to the contrary, the enclosed letter [McElroy to Chairman, JCS] is the result of ARPA initiative commencing last May and reflects exactly the philosophy I have outlined above. Secretary Gates reaffirmed at both his staff council meeting and at the AFPC that the letter reflects precisely the decisions made, and only the decisions made, despite an apparent misinterpretation in certain press articles.... No precipitant

> action with respect to transfer of projects or reorientation of this agency is expected.

Apparently some regular ARPA staff had trouble accepting the space transfer decisions and interpreting their implications because Johnson had to remind Admiral Clark and his division chiefs, "in connection with the considerable discussions that have surrounded the issuance of Secretary McElroy's letter" that McElroy's decisions "reflect my philosophy as to ARPA's role in the DOD space program."[178] Aware that ARPA and IDA staff apparently were resisting the Secretary's directive, he issued a rather stern edict.[179]

> I recognize that political and other considerations may have diffused the precise meaning of the decisions during the past several days. Secretary Gates has, however, reaffirmed the intent of the letter. With respect to political and other considerations related to this general subject, however, these considerations are a function of my immediate office. I shall continue to assign action thereon, as necessary, myself.
>
> It is most important that individual representatives of ARPA and IDA restrict their activities to those assigned, and curtail rigorously any inclination to pursue the subject matter of these decisions outside of channels and without prior coordination within the agency.
>
> It is equally important that the decisions contained within the letter be supported fully and that we now continue with the orderly conduct of our business.
>
> I am sure that you agree with these views and that you will neither undertake yourselves, nor authorize action on the part of your subordinates contrary thereto.

Each of Johnson's surviving senior aides remember clearly, without prompting, that toward the end of his tenure Johnson suddenly lost interest in the job. They cannot pinpoint exactly which straw broke the camel's back -- perhaps York's appointment as DDR&E; perhaps the loss of SATURN (not only from ARPA, but from DOD altogether) on which he had staked so much personally; perhaps the exclusion of ARPA from further work in space; perhaps recognition that he had lost the support of the Secretary and Deputy Secretary and/or their departure from the scene -- but he stayed away from the Pentagon for longer periods, left direction of the Agency to subordinates and made his exit in mid-November 1959.

Johnson's parting public shots regarding the SATURN and inadequate funding and direction for military R&D in general were alluded to earlier. They certainly embellished his image as a shoot-from-the-hip "space bug" at odds with his Administration. He remained convinced that exploration and use of space should be a job primarily for the military (whether or not ARPA did it). His final evaluation of ARPA as an institution, and its future, is another matter and a great deal more complex. Never publicized, it was considerably less passionate. Depending on one's interpretation of the evidence, it either represents Johnson the practical, hard-headed corporate decision-maker or Johnson the defeated, disillusioned leader quietly washing his hands of the whole situation. We lean toward the latter view. There are probably elements of both.

Johnson knew in 1959 that ARPA's future role in DOD was a matter of high level deliberation. He discussed it several times with McElroy, although no record of the substance of these conversations can be found. He discussed it with his senior associates in ARPA as well. The documentary evidence available takes the form of two well-written "think-pieces" prepared in ARPA in late August and early September 1959, each of which carries a brief commentary by Johnson.

The first is an independent evaluation of ARPA's performance and likely future prepared by an Air Force Reserve officer during a two-week active duty assignment in the Policy and Planning Division. The officer, Colonel O. G. Haywood, was a senior vice president of the Huyck Corporation in civilian life and proved to be an astute observer. He talked at great length with people in ARPA, especially the civilian and military staff within Godel's Division, prior to preparing the paper.[180] He pulled no punches in his analysis. Johnson, who knew nothing about Haywood or his work until it was finished, seemed deeply impressed. In any event, he sent the Haywood report to his Chief Scientist, Deputy Director, Assistant Director and three division directors with this instruction:[181]

> It is remarkable that the Colonel should so completely reflect my personal philosophy and views with regard to ARPA. I ask that you read this document carefully and be prepared to discuss this management philosophy in my office.... It is my desire to rearrange this material as a formal statement of management philosophy of the Advanced Research Projects Agency....

The second document is a very carefully drawn quasi-philosophical piece entitled "The Role of ARPA in the Department of Defense." Johnson sent it to Secretary McElroy on September 8, 1959. This was just ten days before the McElroy-York decision that effectively removed ARPA from the outer space scene and about a month before McElroy publicly announced his resignation. Johnson's "Dear Neil" cover letter reads as follows: [182]

> On various occasions during the past year and a half we have discussed the role of the Advanced Research Projects Agency in the Department of Defense. My initial views regarding the course ARPA should take have not substantially changed since my appointment.
>
> You are now leading up to important decisions which must affect the Agency. I honestly believe you should carefully consider the attached staff study, which has been prepared to assist you in understanding and resolving the problems of science and technology confronting the Department of Defense.

Note that the thinkpiece is identified as a staff study. One has the distinct impression that between the lines he is saying, 'I still think ARPA should be at the center of things in DOD, but since that is out of the question for reasons beyond my control, here are some suggestions about using it some other way.' The first draft of the staff study was written principally by Lt. Colonel C. M. Young, Jr., USA, Colonel W. R. Sturges, USAF and one or two others. They believed personally that ARPA should be phased out of existence if it was not to be permitted to continue in space research.[183] But Johnson, in Young's opinion, had come to believe that there was a definite role for a permanent agency to work on problems with a ten year lead time. The Services, Johnson had observed, always concentrated on the short-term and neglected the future. Virtually all of ARPA's space work had been Advanced Development, with some Engineering Development and even some Systems Development. The Johnson idea was to leave that to the Services in the future and devote ARPA to Research and Exploratory Development. The first draft of the staff paper was probably very negative about ARPA's future, but it was then passed to Gise and Godel who essentially finished the document that Johnson sent to the Secretary.[184]

Johnson had concluded that he could no longer ward off the inevitable, namely, NASA primacy in space research and development and Air Force primacy in that portion left to the military by the President. So he instructed the Godel group to prepare a rationale for carving out a niche in the advanced science area that might enable the Agency to survive. Thus this thinkpiece is an amalgam of Johnson's views and his staff's views, looking back on their experiences during the turbulent months since February 1958 and looking ahead to an uncertain future in a policy and bureaucratic setting decidedly different than that which existed when Roy Johnson first came to Washington.

Johnson's commissioned paper explicitly weighed four alternatives: abolishing ARPA, expanding it, making no changes, and redefining its mission. The latter was recommended to the Secretary. The organizational experiment itself of setting up ARPA on the basis of somewhat unique (for Government) management principles, was judged a success. The idea of a small, high quality management group, supported by a scientific and technical staff drawn from industry and the universities on rotation, and using existing DOD capabilities such as labs and procurement systems, had been extremely successful in establishing sound programs in fields of great complexity and fludity. Substantively, ARPA had done a quality job. Johnson received independent confirmation of this belief in Haywood's management critique. Despite a number of specified weaknesses, Haywood deemed the ARPA concept "sound and refreshing" and the Agency's performance promising:[185]

> I do not feel that ARPA faces a real problem of continued existence. It has started soundly. If ARPA continues to demonstrate its competence to manage well the responsibilities it now has and the funds it now has, the DOD will want to assign to it every difficult problem area. The problem will not be continued existence; it will be continuous expansion for a continually expanding scope of responsibility.

Johnson also believed that ARPA had succeeded in limiting the national tendency to expand space programs on the basis of "Sputnik emotionalism" and interservice rivalry, "if by no other means than the development of a single identifiable budget. Similar control within the totality of Military Departmental funding would have been virtually impossible."[186]

On the other hand, it was concluded that the ARPA space monopoly annoyed both the Services and industrial contractors, both of whom preferred decentralization of space responsibilities, the former for roles and missions reasons and the latter as a matter of profits (the looser the control, the greater the opportunity for contracts). Air Force resistance to ARPA was especially strong. Johnson's paper said as much: "Relations with the Military Departments, particularly with the Department of the Air Force, have been complicated by the ARPA space 'monopoly' and the Air Force desire to control use of the space environment." Schriever's public attacks on the Agency faithfully mirrored the unrelenting warfare that went on inside the Pentagon. It was referred to around ARPA as "the Bennie Schriever syndrome."*

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* Nieburg argues flatly that the Air Force succeeded in reducing ARPA to "an empty shell with little real use to anyone," and that it subverted NASA as well. H. L. Nieburg, In the Name of Science (Chicago: Quadrangle, 1970 Revised Ed.) 48-49, 210-211, and 230.

Johnson felt that on balance ARPA had not succeeded in dampening inter-service space rivalries, although it had "performed the valuable negative function of keeping the nation from investing large sums in crackpot ideas."[187] Policy reasons were also cited in the Johnson paper for "decontrolling" space work:[188]

> It has become increasingly apparent that space, as a place and not a system, can become the "heart and soul" of military science, and that space systems development may require decentralized attention by the appropriate Military Departments. This arrangement might better permit use of space to compete for resources with the other environments - land, sea and air - for accomplishment of military missions. Creation of the Director of Defense Research and Engineering as supervisor of all research can serve to limit harmful duplication, as could ultimate creation of a Joint Missile and Space Command.

Ironically, York had "invented" the phrase "space is a place, not a program" in order to put some perspective on the dreams of space enthusiasts, and was fond of using it. York also strongly supported the notion of having space systems compete against conventional systems for funding, although certainly not because he felt space was the "heart and soul" of military science. It was also true, at least in theory, that the new DDR&E could by means of his authority relieve ARPA of the function of preventing Service rivalry.

The most persuasive of the reasons prompting Johnson to redefine ARPA's role, however, was budget. He had learned the hard way that ARPA was not going to be permitted to have large budgets. Indeed the bigger they got, the greater would be the resistance to ARPA. The longer ARPA held on to projects, the greater were their budget requirements -- faced with definite budget restraints, this meant promising research ideas would have to be foregone. It also meant that projects, as they "aged" through the development process, inevitably grew closer to production, deployment and roles and missions controversies and required an immense amount of attention. Having to defend military space systems through these stages taxed a small agency unduly, especially without strong support from the Secretary, and again detracted from other missions. The Haywood critique apparently reinforced these views in a novel way because he recommended that ARPA, as a matter of policy, should not seek increased funding and should not seek additional technical areas in which to work: "I can think of no decision by ARPA which will demonstrate management maturity and profoundness to a greater degree than a decision not to grow."[189] This, he said, would force termination of the least worthwhile projects and encourage rapid transfer of the good ones to the Services for further development and deployment, in order to make way for new projects. Haywood suggested stabilizing the Agency at $500 million. He was propounding the transfer doctrine of Rechtin's ARPA (1968-1970) in its purest form:[190]

> A decision not to grow will require that the ARPA staff periodically make hard technical decisions to cancel projects so that it can start new ones. It will greatly reduce criticisms and doubts as to the long range role of ARPA. It will place increased pressure on the Department of Defense (DOD) level to make timely decisions on roles and missions and assignments of operational responsibilities for weapon systems under development.

Haywood also criticized ARPA's long-range space plan and the planning function itself. The plan, he said, implied future funding levels grossly in excess of available amounts, greatly magnified ARPA's presence in the midst of role and missions disputes, and significantly raised the odds (given Secretarial indecisiveness in making operational assignments for space systems) that ARPA would be drawn into future non-technical policy disputes involving large amounts of Service pride and money, namely, training, logistics, construction, etc. ARPA would of necessity grow bigger and bigger, more and more bureaucratic, less and less unique, and become more like a conventional fourth military department. Aviation Week made the same charge:[191]

> ... ARPA under the aggressive leadership of Roy Johnson ... was charting its course to develop into a 'fifth operation service' [counting the Marine Corps] by taking over all advanced weapons system development for all of the other services....
>
> Ever since ARPA made its 'fifth service' intentions clear, there had been a concerted effort, partially stimulated by valid technical considerations and partially by plain rivalry from other military empires, to either abolish ARPA or radically shift its role in the Pentagon.

This message was not repeated verbatim in the paper Johnson submitted to McElroy. It did not recite all of Haywood's reasoning and nor did it explicitly say the Agency should not grow. But in essence both men came out at the same place. Haywood's conclusions were very consistent with the reformulation of ARPA's role that Johnson propounded. Originally, Johnson's paper argued, ARPA's project assignments were made on the assumption that ARPA would transfer its projects to an operational command when system development had been completed. Experience had shown this assumption to be vulnerable:[192]

> The concentration in ARPA of responsibility for performing military system development, i.e., to the prototype stage, is beginning to affect our over-all capabilities. While a small, top-level staff can effectively plan and manage basic research and special projects, it grows increasingly difficult for it to provide effective management for diverse, complex development of military systems.

ARPA was impressed by the contrast between its space assignments and its other assignments in what many liked to call fundamental or "broad gauge" research areas, namely, advanced ballistic missile defense research, solid propellant chemistry, and the materials sciences. The BMD work was a good case in point:[193]

> In the field of ballistic missile defense, advanced research has been conducted on the broad range of unknowns affecting our ability to cope with the missile threat. For perhaps the first time, the ARPA concept has made possible a fundamental research effort without the intrusion of excessive demands to commit the present "state-of-the-art" to hardware, whether such hardware was adequate to the threat or not. Success in many areas of this broad gauge research has placed ARPA on the threshold of understanding an advanced ballistic missile defense system which will be technically, operationally, and economically feasible....

These comments say as much about the space program as they do about BMD. In any event, Johnson's paper advised the Secretary, in language rather reminiscent of important PSAC themes, that ARPA should devote its energies to basic research:[194]

> ... Defense advanced research projects, whether oriented toward the space or earth environment, are vital to our national security. When systems, particularly in a "high visibility" area such as space, compete for time and attention with the equally vital but more prosaic needs of fundamental research, the latter are likely to suffer. Fundamental research probably requires management unhampered by problems associated with development of military systems. Adequate defense of this advanced research before the Executive and Legislative Branches of the Government can be increasingly limited by need to defend development of military

space systems, which could otherwise be defended by the Military Departments.

Thus the prophet of space systems, or at least his staff with his blessing, suggested a new role for the Agency -- basic research -- one which was to flourish during the encumbancies of J. P. Ruina and R. L. Sproull.

The Johnson paper's final and formal recommendations to the Secretary included the following:

1. Public announcement of the transfer dates of all ARPA space projects and of the new criterion for transfer, namely, completion of research leading to the "feasibility demonstration" of a potential system, rather than completion of system development. "This announcement should have the salutory effect of ceasing ARPA's undesirable identification as the sole military space agency."

2. Clarify all other work assigned to ARPA and consider consolidating several Service basic research programs in ARPA (this approach was to be tested in the Betts period).

3. "Re-state the ARPA organizational stature to include continuation of its (a) line agency status reporting directly to the Secretary of Defense, (b) direct contract relationship with other agencies and industry, (c) IDA relationship which has been very satisfactory and has been so successfully defended before Congress, and (d) independent appropriations structure." (These steps were taken, save the first.)

The paper explains rather well what happened in that turbulent period between the tail end of 1957 when McElroy proposed setting up ARPA to deal comprehensively with "the vast weapons systems of the future" and January 1960 when Secretary Gates chose to refer to ARPA, very briefly, as an agency that undertakes "certain basic research assignments."

The "basic research" theme, potentially, would bring ARPA more in line with the thinking of the President's science advisers. Killian says that initially he and PSAC tended to look on the new ARPA as their own "window into the DOD," as a group that would take on advanced, really "far out" research, such as ballistic missile defense, and pursue it without the parochialism inherent in the Services.[195] York's selection as Chief Scientist led to "extraordinary cooperation and exchange between the White House group and DOD," which did not exist until he went to the Pentagon.[196] Unfortunately, from the PSAC point of view, Roy Johnson's domination of ARPA and York's subsequent departure reduced ARPA's credibility. Killian says that when York left, "the tendency to give ARPA the great spread of responsibilities was thinned out."[197] If he had stayed, ARPA might have been asked to take on important new programs. It is most ironic that the science advisers who made the intellectual case for "advanced research" were alienated by the agency set up specifically to do it. Attempting to overcome that alienation was a task for future Directors.

ARPA, for its part, felt just as bitter about the White House scientists. One striking impression that comes from reviewing the Roy Johnson period is the fact that almost without exception none of ARPA's activities are ever described or justified as "Presidential issues." That phrase was to be used many years later by a different ARPA leadership generation. Instead of appealing to the fact that all its assignments had direct roots to the White House, ARPA's "space age" leadership underscored their contempt for "woolly-headed" scientists by ignoring that legacy altogether. Thus tempers matched the tenor of the times. Admiral Clark let it be known early (June 1958) that there was "too much conservatism in high presidential advisory circles."[198] Roy Johnson ended his tenure as Director with the observation that too many people in government had the authority to stop things, but were not responsible for the consequences of their acts. A case in point, the Science Adviser:[200]

> I think that there must be greater responsibility assigned to the Office of the Scientific Adviser to the President, or it ought to be eliminated. In other words, I do not believe that you can continue to have this kind of power without responsibility.

In retrospect, Godel concurs that the ARPA leadership made an egregious error in thumbing its nose at "the scientists." He said that ARPA simply ignored the Defense Science Board and often failed to give the IDA staff enough credit for its work. He said that at the time they all "thought that Jim Killian was a horse's ass" and when Dr. Golovin, Director of TOD, moved to the Office of Science and Technology ARPA conspicuously failed to make any attempt to use him. Speaking generally about the scientists, Godel said that "we mistreated them ... and in the process we did alienate the scientific community, the hand that feeds."[201] To top it off, ARPA was blissfully ignorant of the deep hostility that existed at the White House toward Roy Johnson and ARPA. This he considers a major failure in the ARPA leadership (himself included). ARPA never even considered making an attempt to sit down with Killian or Kistiakowsky to seek some common ground. The "pride goeth before a fall" maxim was completely verified.

Nonetheless Killian and the prominent scientists associated with him remained adamant that the imbalance in U.S. support of basic research was hazardous to the economy and security of the country and hence must be corrected as a matter of priority if future Sputniks were to be prevented. ARPA was now gearing itself, on paper at least, to address the issue he so urgently emphasized:[202]

> The need, relatively for more basic research drives to the heart of the qualitative problem we face. Our great effort in the field of development can be made more useful and productive if ti can be enriched by the vitamins of basic research activity of greater scope and higher quality than we now support.... In research the first requirement to achieve ... augmented quality is to do more and better work at the basic research end of the spectrum.... Our deficiency is at the very top, in the area over and above the first-rate, where the great intellectual breakthroughs occur, where the great concepts and discoveries originate that appear only a few times in each century.

This vision certainly was not Roy Johnson's cup of tea. His immediate successor, General A. W. Betts, presided over a transitional period of consolidation and retrenchment in ARPA. The next three Directors -- Ruina, Sproull and Herzfeld -- moved a long way, relatively speaking, toward capturing the spirit of Killian's exhortation.* When their roughly six year span had run its course, the bloom was off the rose of "pure science" or "quality science" per se and the cycle had moved closer again to considerations of the "relevance" of R&D work to DOD

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* It is unnecessary here to engage in the endless debate over what constitutes basic research or pure science. For some scientists, ARPA never has done basic research, e.g., as Charles Townes has paraphrased that view: "There is no science coming out of ARPA -- it's technology, or at best applied work." Many consider ARPA's work in pioneering the development of computer time-sharing as important, high quality basic research, but to others "time-sharing is engineering," not science -- "some scientists wouldn't even know ARPA was involved." Even the very esoteric physics work undertaken in DEFENDER would not quality as a "scientist's science. It is really applied work in the sense that it is not what he would normally do just for fun," i.e., a scientist would work on reentry physics only to be useful, not because he thought it was interesting per se. On this standard of judgment, only ARPA's materials science program would be considered obvious, substantial work in science and that, according to Townes, "is well-appreciated." (Discussion with Dr. Charles Townes, July 10, 1975.)

needs, a vector that tends to target research managers on observable systems and near-term results rather than on high-risk, high-gain, long-run "breakthrough" possibilities.

Was it all a mistake, this notion of creating a super science agency to preside over the space race? York's logic in transferring most of the military space responsibility to the Air Force in 1959 has substantial appeal. But asked why Air Force should not have been given the space assignment in the first place, York says:[203]

> Well, because of the confusion that existed about space, and the notion that we were overlooking something, and that you couldn't even trust the Air Force to do it right.... Everybody was working every place. There were many tens, perhaps even a hundred programs on plasma and other forms of electric propulsion. And anybody could get ahold of his Congressman and say 'electric propulsion is the solution to America's problems, and I've got this program, but they [DOD] won't go ahead.'
>
> So, the number of proposals was enormous. The confusion that these proposals created was very great, and the solution to pull it together at a higher level was probably a good one because interservice rivalry was able to feed on that kind of confusion. Had you tried to make just a small office, or give the problem to Holaday -- saying here, divide these up among the Services -- it would have been complete chaos. Conceivably you could have given the whole thing to the Air Force, but you know, that was the period when they were unable to decide between the Thor and the Jupiter. So, if they couldn't decide <u>that</u>, a single program....
>
> You had to have someone -- you had to go to a higher authority to be able to say 'no, the moon is not high ground, we don't have to have a program to capture the moon before the Russians do because the moon is high ground and all army commanders understand that by controlling the high ground you control the ground around it.'
>
> That's the kind of thing we were faced with. It required a higher authority that was 'higher' in both the intellectual and the administrative sense. The guy who <u>denied</u> that the moon <u>had</u> to be captured in behalf of the United States <u>had</u> to be in a position above the Service and also had to be believable for intellectual reasons. It was a mess, it really was.

ARPA coped with "the mess" until events suggested different solutions, notably NASA and the DDR&E and a strengthened OSD at the organizational level, and a clearer, less emotional appreciation of the limitation of both the Soviet threat and the space environment itself at the substantive level. With all its faults and flaws, ARPA cut a remarkable swath between February 1958 and November 1959. It was, however, left completely exhausted by the effort.

CHAPTER III: FOOTNOTES

1. Described in Memorandum for the National Aeronautics and Space Council from Donald A. Quarles, Acting Secretary of Defense, "Priorities for Satellite Programs," March 26, 1959.

2. Discussion with Col. Dent Lay, June 17, 1975.

3. Ibid.

4. Discussion with Adm. John E. Clark.

5. Aviation Week, June 16, 1958, 84.

6. Discussion with Brig. Gen. Charles M. Young, Jr., USA (Ret.), June 11, 1975. Young and Air Force Col. W. R. Sturges conducted this and succeeding planning exercises in 1958-1959. Unless otherwise noted, the information in this paragraph is drawn primarily from General Young.

7. DDR&E (SAGMSO), "ARPA Plan" spread sheet, July 15, 1959.

8. DDR&E (SAGMSO), "ARPA Plan" spread sheet, August 15, 1959.

9. Senate Special Committee on Space and Astronautics, National Aeronautics and Space Act, Hearings, 85th Cong., 1st Sess., May 7, 1959, 162.

10. Letter to Rep. John W. McCormack from Roy W. Johnson, November 25, 1958 which forwards a paper by Herbert F. York entitled "The Next Ten Years in Space."

11. Memorandum for the Secretary of Defense from Roy W. Johnson, "ARPA FY 1961 Budget Request," August 3, 1959.

12. Memorandum for the Chairman, JCS from Neil McElroy, "Long Range Advanced Research Plan of ARPA," August 10, 1959.

13. Memorandum to Donald A. Quarles from Roy W. Johnson, "FY 1959 Space Budget," July 9, 1958.

14. Memorandum for the Special Assistant for Science & Technology [Dr. Killian] from Robert O. Piland, "Results of Preliminary Review of NASA-ARPA Proposed 1960 Space Budget," November 13, 1958.

15. The most comprehensive listing of Service requirements is found in ARPA, "Long Range Plan for Advanced Research," Section I (1960-1964) (Abridged) July 30, 1959.

16. Memorandum for the Director, ARPA from Thomas S. Gates, Jr., June 30, 1959.

17. ARPA, "Long Range Plan for Advanced Research."

18. Memorandum for the Secretary of Defense from N. F. Twining, Chairman, JCS, "Long-Range Advanced Research Plan of ARPA," JCSM-352-59, August 27, 1959.

19. Letter to C. F. Ducander, Executive Director and Chief Counsel, House Committee on Science and Astronautics from Herbert F. York, December 30, 1959.

20. House Subcommittee on DOD Appropriations, Department of Defense Appropriations for 1959, Hearings, 85th Cong., 2nd Sess., April 23, 1958, 323.

21. Each of these assignments was received in the form of a Memorandum for the Secretary from Dwight D. Eisenhower on the dates given in the text.

22. See Memoranda for the Secretaries of Army, Navy and Air Force from Roy W. Johnson, "Study Contracts for Projects Assigned to the Advanced Research Projects Agency," dated July 30, 1958, August 26, 1958 and March 3, 1959.

23. Memoranda for the Secretaries of Army, Navy and Air Force from Roy W. Johnson, "Study Contracts for Projects Assigned to the Advanced Research Projects Agency," September 14, 1959.

24. See Memorandum for the Secretary of Defense from A. J. Goodpaster, Staff Secretary, The White House, July 9, 1959; Memorandum for General Goodpaster from Thomas S. Gates, Deputy Secretary of Defense, "Military Contracts for Space Activities," July 27, 1959; Covering Brief to the Secretary of Defense from the Director of Defense Research and Engineering, "To provide reply to oral question from the President to you on space studies," August 17, 1959; and Letter to the President from Neil McElroy, August 18, 1959.

25. Prepared remarks by R. W. Johnson at a Meeting of the Board of Trustees, IDA, October 24, 1958.

26. Memorandum for Secretary Quarles from Roy W. Johnson, "Status of ARPA Space Programs," June 16, 1958.

27. Ibid. and Memorandum for the Assistant Secretary of Defense (ISA) from the Deputy Director of ARPA (John E. Clark, signed L. P. Gise), "The Department of Defense Scientific Satellite Program," June 4, 1958.

28. Letter to the President from Donald A. Quarles, July 11, 1958 and Covering Brief from Director ARPA to the Secretary of Defense, "To Launch a 100-foot High Visibility Inflatable Satellite," June 30, 1958.

29. See the series of reports initiated by William H. Holaday in 1957 called Monthly Report on Progress of the Scientific Earth Satellite Program, which was continued by ARPA effective with the Report for March 1958. ARPA changed the title of the series slightly with the May edition, Scientific Earth Satellite Program: Progress Report, and closed out the series with the September edition.

30. The information in this paragraph is drawn from ARPA, Military Reconnaissance Satellite Program, Progress Report, Quarter Ending 31 March 1958, 2 and Richard Chapman, Tiros-Nimbus: Administrative, Political, and Technological Problems of Developing U. S. Weather Satellite (Syracuse: Inter-University Case Program, Revised July 1968) 7-11.

31. Memorandum for the Secretary of Defense from James Douglas, "Reconnaissance Satellite," February 1, 1958.

32. See ARPA, Military Reconnaissance Satellite Program, Progress Report, Quarter Ending 31 March 1958 and Quarter Ending 30 June 1958, passim., and the testimony of Dr. Herbert F. York in House Subcommittee on DOD Appropriations, Department of Defense Appropriations for 1959, Hearings, 85th Congress, 2nd Session, especially pp. 304-307.

33. Letter to Major General B. A. Schriever from Roy W. Johnson, October 20, 1958.

34. The information in this and succeeding paragraphs in the Weather Satellite section is drawn primarily from Chapman, op. cit., 1-37 and Senate Committee on Aeronautical and Space Sciences, Meterological Satellites, Library of Congress Staff Report, 87th Congress, 2nd Session, March 29, 1962, 26-35 and 96-100.

35. Memorandum for Mr. Quarles from Roy W. Johnson, "Proposed Space Program for ARPA," March 4, 1958 and York to Johnson attachment.

36. Chapman, op. cit., 8-9.

37. Ibid., 10.

38. Letter to Maj. Gen. B. A. Schriever from Roy W. Johnson, October 20, 1958.

39. R. B. Canright, "The ARPA Vehicle Development Program" IDA-IM-41, March 30, 1959, 2-3.

40. Letter to Carl T. Durham, Chairman, Joint Committee on Atomic Energy from Herbert B. Loper, Assistant to the Secretary of Defense (Atomic Energy), July 1, 1958.

41. Letter to William M. Holaday, Director of Guided Missiles from Lewis Strauss, February 24, 1958.

42. See Memorandum for Deputy Secretary of Defense from Paul D. Foote, Assistant Secretary for Research and Engineering, "General Dynamics Proposal for Space Propulsion," June 17, 1958; Memorandum for Director ARPA from Donald A. Quarles, "Nuclear Bomb-Propelled Space Vehicle," June 18, 1958 and the related Cover Brief from the Director ARPA to the Secretary of Defense June 6, 1958, annotated by Quarles; and the Loper letter at ref. 40.

43. See reference 21.

44. See, for example, Aviation Week, June 16, 1958, 83.

45. Discussion with Adm. J. E. Clark, July 8, 1975.

46. Memorandum to James O. Spriggs, Special Assistant to the Chief Scientist, ARPA from Richard Hirsh, OCB Staff Representative, "Correspondence from Mr. Mark L. Hykin re Propaganda Launch," July 9, 1958.

47. Letter to the President from Donald A. Quarles, Deputy Secretary of Defense, August 7, 1958.

48. Ibid., showing President Eisenhower's approval dated August 15, 1958 and Discussion with W. H. Godel, June 18, 1975.

49. Discussion with W. H. Godel, June 18, 1975.

50. Discussion with Dr. H. F. York, April 4, 1975.

51. House Select Committee on Astronautics and Space Exploration, Astronautics and Space Exploration, Hearings, 85th Cong., 2nd Sess., April 15-30 and May 1-12, 1958, 1105-06.

52. Ibid., 718.

53. House Subcommittee on Defense Appropriations, Department of Defense Appropriations for 1959, 85th Cong., 2nd Sess., April 23, 1958, 309.

54. Senate Special Committee on Space and Astronautics, National Aeronautics and Space Act, Hearings, 85th Cong., 2nd Sess., May 6-18, 183-84.

55. House Select Committee on Astronautics and Space Exploration, op. cit., 1165.

56. Senate Special Committee on Space and Astronautics, op. cit., 149.

57. Ibid., 150.

58. Ibid., 168-69.

59. Ibid., passim and New York Times, May 8, 1958.

60. Discussion with Dr. J. R. Killian, Jr., May 8, 1975.

61. Ibid.

62. Senate Special Committee on Space and Astronautics, op. cit., 169.

63. Memorandum to the Secretary of Defense from Roy W. Johnson, July 23, 1958.

64. For example, Navy Captain Robert Truax cited in Aviation Week, October 10, 1958, 26 and D. A. Young of ARPD/IDA cited in Aviation Week, March 30, 1959, 34.

65. See Memoranda entitled "ARPA Policy Respecting DOD/NASA Relationships" sent by Roy W. Johnson to the ARPA-IDA/ARPD Staff on October 14, 1958 and to the Secretary of Defense on October 15, 1958.

66. Memorandum for Mr. Quarles from Roy W. Johnson "Proposed ARPA Space Program," March 4, 1958 and Memorandum for the Secretary of Defense from Roy W. Johnson, "ARPA Space Program," March 17, 1958.

67. Handwritten note by Deputy Secretary Quarles on SD14 routing form dated August 11, 1958, CCS Control No. 0940-58, which served as cover sheet for the Memorandum to the Secretary of Defense from Wilbur M. Brucker, Secretary of the Army," Project 'ADAM'," August 8, 1958.

68. Memorandum for Director, ARPA from Garrison Norton, Assistant Secretary of the Navy (Air), "Recommendation of Project MER and Project FLY-UP," April 24, 1958 and Letter to John A. Carstarphen, Jr., House Science and Astronautics Committee, from Roy W. Johnson, dated October 29, 1959 and the attached paper entitled "Chronology of DOD Man-In-Space Activities" (hereafter cited as MIS Chrono.).

69. Memorandum for the Secretary of Defense from Wilbur M. Brucker, "Project 'ADAM'," August 8, 1958; Memorandum for the Secretary of Defense from Roy W. Johnson, "Project 'ADAM', August 14, 1958; and MIS Chrono.

70. Memorandum for the Secretary of the Air Force from Roy W. Johnson, "Reconnaissance Satellites and Manned Space Exploration," February 28, 1958 and Johnson's testimony, House Subcommittee on DOD Appropriations, Department of Defense Appropriations for 1959, Hearings, 330.

71. Memorandum for the Under Secretary of the Air Force from Roy W. Johnson, "Air Force 'Man in Space Soonest' Proposal," June 12, 1958 and MIS Chrono.

72. House Subcommittee on DOD Appropriations, Department of Defense Appropriations for 1959, Hearings, 308-09.

73. Letter to John W. McCormick from Roy W. Johnson, November 25, 1958.

74. Memorandum for the Secretary and Deputy Secretary of Defense from Roy W. Johnson, "ARPA Fiscal Year 1958-1959 Budget," July 2, 1958.

75. Memorandum for Dr. James R. Killian from Admiral John E. Clark, July 23, 1958.

76. President's Science Advisory Committee, "Introduction to Outer Space," The White House, March 26, 1958, 15.

77. House Committee on Science and Astronautics, To Amend the National Aeronautics and Space Act of 1958, Hearings, 86th Cong., 2nd Sess., March 30, 1960, 403.

78. Ibid., 425.

79. See, for example, Memorandum for Roy W. Johnson from S. B. Batdorf, "Present Status of Man-in-Space Program," October 2, 1958; Memorandum for File from S. B. Batdorf, "Presentation of MIS Program to Dr. Glennan," October 14, 1958; Letter to Roy W. Johnson from T. Keith Glennan, November 14, 1958; and L. P. Gise, "Comments on Man-in-Space," noted dated June 7, 1958.

80. MIS Chrono.

81. Eugene M. Emme, A History of Space Flight (New York: Holt Rinehart and Winston, 1965) 162-63.

82. Memorandum for the Administrator, NASA from Roy W. Johnson, "Man-in-Space Program," September 3, 1958.

83. Senate Special Committee on Space & Astronautics, Hearings National Aeronautics and Space Act, 85th Cong., 2nd Sess., May 7, 1958, 159 and 165, 167 and 170. See also Memorandum for File from S. B. Batdorf, "Presentation of MIS Program," October 14, 1958.

84. Memorandum for the Director, ARPA from Donald A. Quarles, "Super-Thrust Rocket Engines," June 23, 1958.

85. In addition to the March 30, 1960 Johnson testimony noted in ref. 77, see, for example, Memorandum for the Deputy Secretary of Defense from Roy W. Johnson, "'Clustered' 1-1.5 Million Pound Thrust Booster," September 5, 1958 and Memorandum for the Assistant Secretary of Defense (Supply and Logistics), "Nomination of the 1.5 Million Pound Thrust Clustered Engine Booster (SATURN) for Inclusion in the 'S (Brick-Bat .01)' Category of the Master Urgency List," October 13, 1959.

86. Discussion with Brig. Gen. C. M. Young, Jr., June 11, 1975.

87. Missiles and Rockets, November 2, 1959, 2.

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89. Memorandum for the Deputy Secretary of Def[illegible] from Roy W. Johnson, "1.5 Million Pound Cluster[illegible] Booster," October 9, 1958.

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91. Missiles and Rockets, November 30, 1959, 35.

92. See the Johnson to ASD (S&L) memo in ref. 85 above, which references a memorandum from the Chairman, CMLC to the Secretary of Defense on the National Space Vehicle Program, dated September 30, 1959.

93. Missiles and Rockets, November 2, 1959, 12.

94. House Committee on Science and Astronautics, op. cit., 409.

95. Ibid., 410.

96. Discussion with Dr. H. F. York, April 4, 1975.

97. Discussion with W. H. Godel, June 18, 1975.

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126. Discussion with Dr. H. F. York, April 4, 1975.

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198. Aviation Week, June 16, 1958, 292.

199. Discussion with Adm. J. E. Clark, July 8, 1975.

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202. James R. Killian, Jr., "The 'Growing Edge' of Innovation," Address to the Economic Club of Detroit, February 23, 1959.

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Chapter IV

RETRENCHMENT AND ACCOMMODATION

THE BETTS PERIOD: 1960

The transition between Roy Johnson's departure and the arrival of Brigadier General Austin W. Betts as ARPA Director was far from smooth. Despite Johnson's efforts to ease the problems created by ARPA's loss of the space programs by building a case for a broader ARPA mission emphasizing basic research, it was a time of great uncertainty. At the least it ranks with two later crises in ARPA's institutional history that were also associated with changes in Directors: the 1967 transition from Herzfeld to Rechtin and the 1970 period prior to Lukasik's appointment when Rechtin had turned most of his energies to a new DDR&E assignment and the Agency was clearly drifting.

In most respects, however, the late-1959 period was probably more ominous than any crisis which followed. The space loss was a clear demotion, the new programs were not solidly established, the DDR&E's prospective view of the "new" ARPA was quite unclear, and cries for ARPA's abolition continued. The actual and planned stripping of space projects for transfer to NASA and the Services left ARPA with about a $150 million budget. As one who lived through this period put it: "We went from being a halcyon agency to being just another source of funds."[1] Many questioned why a separate organization was needed at that program level. Publicly, various sympathetic and unsympathetic critics were busy preparing the Agency for burial:[2]

> The first stepchild of the space age seems rapidly on its way out the nearest and most convenient exit; convenience being merely the covering phraseology for official embarrassment at having a dead cat hanging in the fruit closet.... There's no question but that ARPA now lives on borrowed time.... Either we need ARPA or we don't -- and events seem to establish clearly that ARPA is regarded as an organization that 'must go.'
>
> Instead of bleeding it into lifelessness, why not simply carry out the near-corpse? A case of conscience? (Underline in original.)

On top of all this, the selection of a new Director, Dr. Charles Critchfield, became a high visibility public issue, culminating in his withdrawal from the position, thereby leaving ARPA in even greater chaos.

The Critchfield Episode

As part of his desire to leave an accepted, continuing ARPA as a legacy of his less than two years as Director, Johnson had agreed at McElroy's request to search for and nominate his successor. It was not an easy task because the obvious dismantling of the Agency's programs did little to burnish its attractiveness. For those interested in outer space especially, NASA was the place to go. Nonetheless, after conversations with Deputy Secretary Gates, Johnson reviewed a "considerable list" of candidates and recommended Dr. Critchfield in late October. Described by Johnson as "eminently qualified in every respect for appointment,"[3] Critchfield indeed appeared to be an excellent choice. On paper he combined, to an extent probably greater than any of ARPA's directors, the qualifications of both a scientist and an industrial manager experienced in advanced research. Critchfield was, in Johnson's words, "a theoretical physicist of the first rank."[4] He had been associated with the atom bomb development effort, and had been professor of physics at the University of Michigan (with teaching experience at Rochester, Princeton and Harvard). At the time of his appointment, Critchfield was Director of Research for the Convair Division of General Dynamics and head of Convair's advanced research laboratory. He was Johnson's clear first choice over an alternative selection who shared Johnson's business management background, but lacked Critchfield's scientific credentials. Although Johnson actually "couldn't have cared less who came in" to replace him, he was given the green light to open negotiations for Critchfield's services with Frank Pace, President of General Dynamics.[5]

Critchfield accepted the appointment in early November. It met with generally favorable press response, including coverage in Time magazine.[6] Critchfield's acceptance was, however, conditional and the conditions immediately gave rise to a storm of Congressional protest. Essentially due to his high Convair salary of approximately $40,000 (better than double the pay scale for the ARPA Director), Critchfield demanded that he be hired as a "without compensation" (WOC) employee, with the government allowing him $15 per day expenses and permitting him to retain his Convair salary. Critchfield, in turn, committed himself to take no hand in any ARPA decisions involving Convair (whose contracts then amounted to $4 million of ARPA's $500 million budget, mostly concerned with space projects in process of transfer). There was precedent for this sort of arrangement under Section 704 of the Second Supplemental Appropriations Act of 1951, which explicitly authorized the Secretary of Defense to hire up to ten people under such procedures. Dr. York had served as ARPA Chief Scientist in a somewhat similar situation as did the encumbent Chief Scientist (Dr. George Sutton) and five others in OSD/DDR&E.[7]

Despite precedents, Congressional opposition to the appointment rose sharply, led by Congressman Chet Holifield of California, who attacked this arrangement on conflict of interest grounds.[8] According to rather vague memories of then-current ARPA staff members, Critchfield arrived briefly in the Pentagon and defended the propriety of his appointment, but in a manner thought by some to be counter-productive. The event caused great consternation at the Secretarial and DDR&E levels. Defense-industry relations were under attack at the time from a number of directions, and the appointment proved non-sustainable under nationwide exposure. Pace also told Gates that he feared a stockholder suit over the issue.[9] The Secretary instructed Gise that it would be necessary to back out of the appointment. On November 15 Critchfield withdrew his acceptance, accompanied by expressions of regret from the Secretary. ARPA was left without a current head (Johnson had departed) or a prospective Director.

The Betts Selection

The aftermath of the Critchfield episode was a search over approximately one month for a candidate Director unlikely to arouse Congressional criticism.* Ultimately the search led away from individuals with an industrial connection subject to "conflict of interest" attacks and toward a candidate from within the DOD, and eventually to General Betts, then on the DDR&E staff. Described by York as an objective and "reasonable" man, fundamentally in agreement with the DDR&E on central space-related issues, Betts was regarded as a solid team player, unlikely to engage in contentious controversy but still with "a kind of both good sense and courage, and a willingness to think independently even at some risk [to his Army career], that was good."[10] Bett's integrity and objectivity were respected in DOD, even by the Air Force (he had supported the decision to separate ABMA/von Braun from the Army and he failed to see the time urgency which Johnson and others associated with SATURN).

General Betts was a 1934 West Point graduate with a masters degree in engineering from MIT who had carved out a solid career in military research and development. His previous posts included Associate Director of the Los Alamos Scientific Laboratory, Chief of the Atomic Energy Branch of the Army's Research and Development Division (G-4), Chief of the Combat Development Branch - USAREUR, Engineer of the Army Ballistic Missile Agency at Huntsville, Army advisor to the Special Assistant to the Secretary of Defense for Guided Missiles and, in his last pre-ARPA position, Military Assistant (Army) to the DDR&E.

The selection of a military man as Director came as a surprise to the staff. Military officers within ARPA interpreted it as a sure sign that the Agency was going to be downgraded and phased out. General Betts, however, says that York did not discuss eliminating ARPA with him.[11] Neither did York intimate that he should look on the appointment as a permanent tour of duty. It was a sort of stop gap or "marking time" appointment. As Godel put it, "Betts knew himself that he would never have the authority to make it [ARPA] swing."[12] Senior staff considered the newly-arrived

* In the interim, Air Force Major General Donald Ostrander, who had succeeded Admiral Clark as the Deputy, served as Acting Director.

Betts to be impartial, a "stabilizer" but quite skeptical about ARPA and its value. He later developed lots of enthusiasm and "came to believe in a role for ARPA."[13]

In the interim preceding Betts' appointment, the leaderless ARPA pondered its future role. Staff morale was quite low. A concept paper and comments thereon circulated among the Acting Director and the Directors of TOD (Golovin) and Financial Management (Bolton) during late November.[14] They reveal the uncertainty felt in the organization and its total dependence on the DDR&E. The papers indicate that ARPA must "avoid contentiousness," be a "service agency," and "should be subordinated" to the DDR&E. The "lack ... of a clearly defined sense of direction and adequate work assignments" is bemoaned. Golovin, in particular, indicates that the future direction of whatever "ultimate agency" might derive from ARPA is completely unclear, and notes that many of ARPA's functions could be absorbed within DDR&E. The need to "help effectively in areas assigned by DDR&E when any defense research activity or project requires help" is stressed.

The leadership vacuum growing out of the abortive Critchfield appointment and the eventual selection of a DDR&E staff member, General Betts, as ARPA Director thus completed the subordination of ARPA to DDR&E against which Johnson had unsuccessfully battled since DDR&E's creation. Shortly after Betts' appointment this subordination became codified in a new ARPA directive. The independence or "semi-independence" cherished by ARPA in the Johnson era was to be largely submerged in the Betts period, reappearing slowly with increased delegation of authority to ARPA Directors under York's successor, Dr. Harold Brown, and the development of considerable autonomy in ARPA's individual program offices.

Charter Revision

General Betts' arrival at ARPA coincided with an administrative change removing the ambiguity in ARPA authority and responsibility vis-a-vis the Director of Defense Research and Engineering. This change placed ARPA clearly and decisively in a subordinate role to DDR&E.

On March 17, 1959, it will be recalled, the initial ARPA directive had been revised, taking into account the creation of DDR&E but preserving -- at least on paper -- the direct line between ARPA and the Secretary. The key wording of the March 1959, directive is as follows:[15]

> Pursuant to the authority vested in the Secretary of Defense ... an Advanced Research Projects Agency is hereby established as an operating research and development agency of the Department of Defense under the direction, authority and control of the Secretary of Defense. (Underline added.)

The directive goes on to say:

> The assigned projects of the Agency will be subject to the supervision and coordination of the Director of Defense Research and Engineering in the same manner as those of the military departments and will be conducted in accordance with the priorities established by the Secretary of Defense.

Thus, the March 1959 Directive recognizes the authority of DDR&E over ARPA, while preserving the "direct line to the Secretary" given to Roy Johnson.

With the appointment of General Betts the groundwork is laid for unambiguous assertion of DDR&E control over ARPA. Thus on December 30, 1959 -- only a few days after the Betts appointment -- a new directive is issued. The key wording is as follows:[16]

> Pursuant to the authority vested in the Secretary of Defense ... an Advanced Research Projects Agency is hereby established as an operating research and development agency of the Department of Defense under the direction and supervision of the <u>Director of Defense Research and Engineering</u>. (Underline added.)

The directive continues:

> The Advanced Research Projects Agency will be separately organized within the Department of Defense under a Director of Advanced Research Projects appointed by the Secretary of Defense. The Agency will be responsible for basic and applied research and development for such advanced projects as the Director of Defense Research and Engineering assigns.

There is no mention of direct Secretary of Defense policy guidance or specification of "priorities," except a subsequent notation that ARPA may perform "such other functions as the Secretary of Defense or the Director of Defense Research and Engineering assigns," this replacing a similar line in the March directive that mentioned only the Secretary. Elsewhere in the December directive, mention of ARPA responsibilities to the Secretary is expurgated in four paragraphs where such reference was previously contained. Finally, the responsibility for project assignments is given to the DDR&E, rather than (as previously worded) the Secretary of Defense "upon recommendation" by DDR&E.

Thus the clear intent of the December 1959 charter modifications is more clearly and firmly to subordinate ARPA to DDR&E. This modified directive proved to be lasting. It endured until March 1972 when ARPA was established as a separate Defense Agency.

That General Betts accepted this subordinate role to DDR&E is thoroughly supported by his FY 1961 testimony to the House Appropriations Committee. In responding to questioning from Chairman Mahon he specifically denies any independent role vis-a-vis the Secretary but defends the DDR&E's need for a "central mechanism" such as ARPA:[17]

> General Betts:
>
> ... I look to Dr. York for my technical direction. He is my immediate superior for direction of the programs I have. My program assignments come to me signed 'Dr. York.' They do not come from the Secretary by direct means.
>
> Mr. Mahon:
>
> Do you think this is a satisfactory and thoroughly workable arrangement, and do you believe that it should be continued?
>
> General Betts:
>
> I firmly believe in this mechanism for accomplishing certain programs. The important thing is that we must be very careful about the nature of the programs that are assigned to ARPA. For example, if as a result of the ARPA effort we demonstrate, in a real sense, the feasibility of a satellite-based ballistic missile defense system, then it would appear to me that the great American press might immediately blow this up into an ARPA-versus-services fight for the money for ballistic missile defense. Since we are, in fact, working hand in glove with the services in a very real way, I think we can ride through any such criticism of our program and keep it on a very solid, technical basis. Surely you have a great deal of familiarity with just what happens where a new idea is in one service and the going program is in another service. So, for those areas that are very highly controversial or that feed into the separate services in a very important way, I think the Secretary needs or the Director of Defense Research and Engineering needs a central mechanism to handle certain programs.

Betts' Persnectives on ARPA

York recalls that it was his objective to get ARPA out of the space business, but not to dismember it. He had nothing else special in mind for it to do and had no particular desire to expand it. The post-space program that remained he considered "good" and he claims that he had no real doubts about ARPA's ability:[18]

> I did feel that as the overall situation returned to something more mature or more normal... that one good reason for continuing with ARPA was a means of providing the Secretary of Defense and the Director of Defense R&D with their own capability for accomplishing projects without infinite argument with the Services. But that means that I think ARPA ought, in important ways, to come under the Director of Defense Research and Engineering.

Despite his close relationship to Killian, Kistiakowsky and PSAC generally, York was not a zealot about basic research, and that probably helped confuse things a bit in an ARPA looking for useful "advanced" basic research arguments. York's position is revealing:[19]

> [A]s an ideological matter I felt that it was not true that the Department of Defense is responsible for the health of science and I felt no obligation to expand Defense Department support of basic research for the reason that basic research is important. In fact, the right way to describe my position is that before I left I tolerated basic science in the Defense Department rather than promoted it. I didn't cut it, but I didn't raise it either.

General Betts joined ARPA not only with a sense of obligation to the DDR&E, but also with some degree of reservation concerning his own assignment to the post as a military officer. ARPA, he felt, was an important civilian organization serving DDR&E and the Secretary, and he noted:[20]

> I really didn't feel that we had been too wise about putting a military guy in as Director of ARPA because, inevitably, on one side he would be accused of being partial to his service, and on the other side, by his own Service, he would be accused of being a traitor.... It was perfectly clear that it was a Defense-oriented -- by Defense I mean Office of Secretary of Defense -- oriented operation, mixed up in things that were multi-service in nature,

> and in a very real sense had a great deal of power to use money that the Services very jealously eyed. To put a military guy in that position tended to erode the basic reasons for setting ARPA up in my judgment. And when I left that's why there was no consideration of another military guy to replace me. Hert and I had agreed that when it was my turn to go we would bring in a civilian.

Betts went on to illustrate his view that ARPA needed a civilian director with the following example:[21]

> One of the things that clinched my determination that ARPA should have a civilian head and not a military one was when we were debating the transfer of the ADVENT program to the Services and because it was communications -- it was agreed that it would go to the Army -- but [Air Force General] Schriever in one meeting in the Secretary of Defense office, held forth most effectively that he couldn't possibly do an effective role with the booster system unless he also had full control of the element that it boosted so that the whole interconnect was his responsibility and that all the Army had to do was put in the package for the communicator. The ARPA staff, that was not Army, had gone through the analysis of this thing, and had briefed me as Director of ARPA on all of the reasons why ... and said far and away the tougher problem was going to be the Army's, not Schriever's. Well, in the Secretary of Defense's office here was Schriever arguing from the Air Force side and I think someone from the civilian Secretariat of the Army, arguing from that side, and I was trying to argue objectively what ARPA wanted, but it kept coming out that, 'well, here is parochial Army arguing against Schriever....'

General Betts' reservations concerning his own assignment and his insistence that ARPA should have a civilian character are directly related to his views of the role of ARPA. Specifically, he did not view ARPA primarily in terms of a brilliant technical organization guarding the nation against technological surprise through high-powered advanced research, but rather as a management mechanism to handle research problems otherwise likely to be bedeviled by inter-Service conflicts. The following interview exchange summarizes this view:[22]

> Q: Do you think that ARPA has had a better batting average than most other organizations over the years of being able to spot promising new fields and lay money on the line?

A: I wouldn't try to make a case for their having been sharper in finding new things than anybody else.

Q: What is their strong point?

A: As far as I am concerned their strong suit is [that] they were able to pursue programs that impacted on at least two and sometimes three of the Services and bring them along without things getting into inter-Service warfare. I really think [for example] we would have had some very difficult times on the Hill if the Air Force had gone over with SAMOS program, and the Navy going over with the TRANSIT program ... [but] APPA could present the facade of a single defense program; even though I don't think ARPA or anybody else would have tried to kid the Congress that the work at APL on TRANSIT was being done in a nice cooperative, analytical way with the work on the top end of the SAMOS or some of the Air Force programs. Nevertheless, ARPA did have people on the staff that knew what was going on with each of these well enough, and were technically competent enough, to be able to make sensible judgments as to where these systems ought to come together with some commonality and where it wasn't terribly important.... [Similarly in] Defender, I do think that they [ARPA] managed to bring out strengths and weaknesses of both offensive and defensive systems that were available to both sides. It simply would not have been so completely open and available to both sides if both the Air Force and the Army had been going separate ways.

Amplifying on his view of ARPA as primarily a mechanism for the DDR&E to pursue research involving multi-Service issues, Betts states:[23]

> I couldn't argue effectively for continuation of ARPA other than from the DDR&E point of view. He has programs under his direct and immediate control that he would otherwise be a couple of administrative echelons away from. It's all well and good to say that the Services will do what you want them to do -- in other words, 'sure, just tell us what you want to do but give us the money.' I still think that where a program is multi-Service in its total complexity, that to pull it together in an operating level above the two Services can make for a truly more effective program than if one Service just does it and lets the other string along. And there is

> one other thing that ARPA certainly has: the flexibility to wheel and deal in a way that's terribly difficult when you get to the Service level because there is so much competition for funds ... [that if] you want to change something -- a major change -- in the Service program, it's a very painful process.

Betts was and remains a very strong proponent of DOD support of basic research because he believes it is necessary for the Department to remain "coupled" to the very best thinking that is going on in the universities and other laboratories. He felt that ARPA managed basic research programs admirably and is inclined to think, in retrospect, that a great deal of Service R&D in the 6.1 and 6.2 areas* could be effectively combined in ARPA.

To conclude this synopsis of the Betts view of ARPA's role, his response to the following question concerning ARPA's "technological surprise" mission is revealing:[24]

> Q: One of the rationales for having an ARPA that is repeated to this day ... was that ARPA had a mission of guarding against technological surprise.... Was this something that when you were Director you felt was part of your job or your mission?
>
> A: I don't remember ever being worried about that as an exercise.... I [have] wracked my brains but I can't remember ever treating it as a serious mission of ARPA that we should gaze into our crystal ball and see what kind of technological surprise we were likely to [find]. It seems much too nebulous to put a program together. It sounds like the kind of glory words you put in the mission things to impress Congress and everyone else, without any real substance behind it. Because ARPA had a pretty clear and firm series of programs. And those were the ones we pursued.

The Betts ARPA is thus a quite pragmatic organization, pursuing specific programs assigned by DDR&E which presumably would be more difficult to manage properly in individual Services.

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* 6.1 and 6.2 are the Department of Defense budget categories for "research" (including both basic and applied research) and "exploratory development," respectively. These are the two "early" stages of Defense R&D, later steps being "advanced development" (6.3), "engineering development" (6.4) and "operational development" (in the procurement budget). ARPA's budget is comprised solely of 6.1 and 6.2 funds.

Program Change During the Betts Period

Despite the modest views expressed above, the period during which General Betts was Director of ARPA reads on paper as though it were the most dynamic period of expansion in the Agency's history. A new program called SUNRISE, leading to the formation of the Jason advisory panel, is assigned in January 1960; Energy Conversion research is assigned in July; Arms Control research in September; Toxicology, a broadened propellant program and a "General Research" program in November. The VELA program assignment is publicly announced in May. Programs in Electronics, Climate Control, Command and Control Research and unconventional warfare were announced by June 1961 -- all with apparent origins during General Betts' tenure (which ends in January 1961).[25]

This apparent flowering of ARPA assignments is, however, somewhat misleading, for the Betts period is characterized more by adjustment and accommodation to the space transfers than by a vigorous expansion of work effort. The only ARPA programs to receive substantial funding were those carried over from Roy Johnson's period. The new programs were all small, ranging from under $1 million to about $6 million, whereas the surviving Johnson period assignments in FY 1961 ranged from about $19 million (propellant chemistry) to over $100 million (DEFENDER). Of the projects noted, three might be characterized as ARPA being tapped as a convenient mechanism to address an immediate DDR&E problem (toxicology, arms control, and command and control research); energy conversion and an assignment in "reliability" were minor extensions of space-period efforts; climate control and unconventional warfare efforts were modest ARPA staff initiatives (though the latter grew rapidly after Betts' departure); and the SUNRISE and general research assignments were simply very minor efforts. The expanded propellant chemistry charter was actually a reflection of difficulties in the original work effort, which was limited to solid propellants. To further illustrate the modest contemporary importance of the new initiatives, approximately 94 per cent of the FY 1961 budget was accounted for by four programs initiated during the Johnson period (DEFENDER, VELA, Propellants, Materials) as was 87 per cent of the FY 1962 budget. Thus despite the addition of several new project titles, General Betts left basically the same legacy of non-space programs that he had inherited.

In fact, Betts did not regard the generation of major new ARPA programs as a primary responsibility:[26]

> The major commitment that I worked on was to move some of those big space programs like the Navigation Satellite -- that kind of thing -- to the Services and to get them out of ARPA.

Aside from his commitment to expedite the space program transfers as had been decided in 1959, Betts felt that ARPA should be receptive to new programs. There were, however, no major new assignments from DDR&E and most new activity during the period was developed at ARPA and/or ODDR&E staff levels. Neither Betts nor York apparently gave much attention or priority to these developments:[27]

> You can't move something without thinking about moving other things in to keep up the mission in the organization. As I remember, the conversations I had with Herb York, were to look at the kind of things ARPA should be doing to replace those that we both felt should move out of ARPA. I don't remember specifically each one of those items and the kind of staff work we were doing to justify ARPA being in the act. All of those forces were at play ... I don't remember a great deal of pressure from Herb to pick up specific programs. We were in more or less daily contact with various elements around DDR&E, and those guys always thought of ARPA as where they would go to get something done if they couldn't get it done in the Services. I think some of it [new work] was self-generated and some came from the [DDR&E] Staff, but I don't remember the motivation behind the specific ones.

<u>ARPA Organization</u>

Perhaps General Betts' greatest contribution to the future ARPA was neither creating new nor shaping old assignments, but rather restructuring the Agency in a manner more consistent with program and bureaucratic realities. Arriving in December 1959, Betts inherited a Chief Scientist, Deputy Director, Assistant Director (Administration), the Program Council structure, and three staff divisions, all supported by the IDA Advanced Research Projects Division (ARPD/IDA). By the spring of 1960, however, the substantial change in the ARPA program (particularly the diversity of new assignments) and the desire for decreased reliance upon IDA support, necessitated an Agency reorganization. In May 1960, therefore, the Technical Operations Division was eliminated and separate offices were created for each major ARPA assignment -- ballistic missile defense, nuclear test detection, solid propellant chemistry, materials science and "special projects" (later called "general research" and consisting of miscellaneous smaller assignments).[28] To assist in coordination of these several technical offices, the new position of "Technical Executive," filled by Col. Dent Lay, USAF, was created in the Director's Office. To staff the new technical offices, a considerable addition was made to ARPA's professional roster. The net effect of this change was further to reduce reliance on IDA technical expertise in lieu of in-house staff, and IDA gradually assumed more traditional contractor study and analysis functions and became less involved in program management. ARPA also tried to recruit eminent scientists to fill the DEFENDER and VELA office posts because, as Gise put it, they "were recognized as National programs of great importance and should be attractive to men of scientific stature."[29] (His illustrative candidates for those two positions, respectively, were Harwood of Lincoln Laboratories and Latter of RAND.) Gise also recommended letting the program office directors report directly to the Director, in part to attract such people. ARPA did not lure the top drawer scientists in 1960 but did establish the program offices. Ruina subsequently was to attract excellent people and to give them great authority to operate within their office spheres of influence, subject only to his personal control. Later Directors, critical of this system, were to criticize ARPA as an unintegrated cluster of feudal baronies. Those who got results with it, swear that it is the only way that ARPA can succeed as a multi-faceted, small management agency engaged in advanced research.

Restructuring the ARPA-IDA Relationship. General Betts' reorganization of ARPA largely revolved around the issue of establishing a base of technical competence within the Agency, as opposed to continued reliance on the Institute for Defense Analyses (IDA). As indicated several times in preceding sections, IDA was a major contributor to the ARPA effort in 1958 and 1959, with its presence permeating virtually every aspect of the ARPA program. IDA had provided ARPA's Chief Scientist (Dr. York and his immediate successors) and IDA staff members were co-located with civil servants in ARPA's Pentagon offices. There was often a fine line of distinction at best between the activities of IDA and ARPA employees. This arrangement was crucial to ARPA's ability to gain a measure of control over the multitude of programs assigned the new agency. An ARPA paper prepared in late 1958 called the IDA relationship "the single key factor in this vital undertaking."[30] As Roy Johnson said frequently, the rapid recruitment of IDA staff from industry enabled ARPA to "hit the ground running" with sufficient technical talent to gain a measure of substantive control over its diverse assignments. Even Betts, who engineered the change in IDA's status, was not entirely comfortable about doing it: "I do remember not being particularly happy about making the change, from an operating point of view, because the IDA guys were the strength of our operation."[31]

Even while the ARPA/IDA arrangement was quite new, however, the relationship came under rigorous questioning both within OSD/ARPA and IDA and in Congress. By General Betts' arrival as ARPA Director major changes were unavoidable.

The primary issue in the ARPA/IDA relationship from the beginning was, of course, the conflict of interest question. IDA personnel concerned with the ARPA program were, for the most part, recruited from industry on a leave of absence basis, and thus were deeply involved in major government programs during a brief interval within their industrial careers at a time when firms were vigorously competing for government business. Questions naturally arose as to whether such IDA employees would be in a position to benefit their home companies, to affect competing companies adversely, or to set themselves up for new employment.[32] Gise says that real conflict of interest problems did arise: "This was an exception rather than the rule, but there were quite a few instances where some of these individuals were really trying to create a situation that would be to their benefit after they left ARPA."[33] Moreover, the IDA staff was, despite its formal focus on technical assessment and review and program planning inputs, deeply involved in project development and management. As General Betts was to put it: "[T]he present IDA staff is, on the record, much more interested in serving in a project manager relationship than in a planning relationship."[34] In fact, IDA personnel reviewed projects in Washington and in the field and not only assessed new proposals from a technical viewpoint but made highly specific judgments about the modification, expansion or contraction of project tasks and about funding levels.

As summarized in a May 1959 ARPA staff study, IDA's Advanced Research Projects Division assumed these functions largely by default:[35]

> IDA/ARPD was responsible for reviewing and evaluating these proposals from the technical point of view. Since the management review apparatus in ARPA had not fully evolved in ARPA's early days, IDA/ARPD's technical recommendations usually served as the primary basis for accepting projects and IDA/ARPD people became involved in the subsequent program development. In short, ARPA, recruiting at a less rapid rate than its contractor, lacked the personnel and machinery to adequately review IDA recommendations or to carry out the development and monitoring of programs.

Adding to this politically volatile mixture, ARPA elected to run most of its R&D on the basis of unsolicited proposals. In part this compensated for the very small staff size and was thought as well to cut down on the time wasted by Service procurement agents. Gise was especially worried about this practice during the period when IDA staff were so much involved in the Agency's decision-making:[36]

> I was waiting for the roof to fall in on us any time because it was so well known, throughout the whole scientific community, that the IDA guys were going out and saying 'look, how about giving us this proposal on so and so,' and it [the request] would go to just one guy. But nobody ever complained.

Nonetheless, until brought under control, the situation had unfortunate side effects: "The combination of all this money, some hair-brained ideas, and the emphasis on technology rather than science led some people [scientists] to make fun of ARPA for awhile."[37]

At ARPA's beginning, IDA's potential conflict of interest problems and the difficulty of a private contractor tending to speak for (and make commitments for) the government were overridden by post-Sputnik urgency and IDA's ability quickly to recruit technically-competent professionals from industry. Before the end of Roy Johnson's first year, however, a number of steps were required to lessen the potentially adverse effects of the arrangement. On December 5, 1958, Johnson proposed the following steps "to improve ARPA's effectiveness:"[38]

1) Establish a small Technical Division within ARPA of career service people to carry out the day-to-day direction and supervision of approved projects.

2) Gradually replace IDA 'leave of absence' employees with permanent employees.

3) Relocate the IDA group outside the Pentagon.

In addition, an "ARPA Contract Advisory Board" composed of Civil Service and military personnel was established in October 1958, to review proposals.[39] In February 1959, the review mechanism was formalized in membership and procedures, and reconstituted as the ARPA Program Council, which was continued well into the Ruina period.[40] Although useful in screening proposals to insure that no good idea was neglected and for other purposes touched on in Chapter II above, the Program Council primarily settled down to the task of supervising Agency accountability. It provided a formal mechanism to insure that governmental employees explicitly sanctioned project initiation, selection of contractors, commitment of funds, and related actions. Gise's view of the Program Council is what one might expect from the Agency's top management official:[41]

> We had the IDA staff, a really completely undisciplined group of people who were dashing around madly picking ideas sort of willy-nilly -- not that they weren't good ones but it concerned me because there were possible conflicts of interest. There was really no review of these programs by people who were on the payroll of the Government. This bothered me and so in order to at least give an impression that we had some Government responsibility we set up the Program Council ... where we actually got the IDA people to put their proposals down in writing. Before that, they weren't even doing that.

As imaginative bureaucratically as they often were substantively, the IDA staff were also adroit at getting "approvals" for their ideas from Johnson or Clark, then were off and running in solo performances. York had some difficulty controlling his own staff. The Program Council was a means of bounding this "seat of the pants" form of management.

Up to General Betts' arrival as ARPA Director, however, the hectic pace of the space and BMD projects tended to keep IDA staff members deeply involved in the inner workings of program management. Because of the continued sense of urgency, Johnson proceeded slowly in changing IDA's role. On January 20, 1959, he informed the Secretary of Defense by memorandum that while establishing a small Technical Division staffed by civil servants, he was deferring action on reducing leave of absence staff drawn from industry and on separating IDA employees from ARPA's Pentagon offices.[42] With these IDA leave of absence employees still working along-side ARPA staff in the Pentagon and with TOD functioning with a skeleton civil service staff, IDA influence on ARPA decisions and involvement in program management was still enormous Dr. Charles Townes, who joined IDA in the fall of 1959 just prior to Betts' arrival as ARPA Director, recalls the IDA role in terms that reveal its still-central position in the ARPA effort:[43]

> Our official position was to give advice, like consultants, and not make decisions, but the Pentagon literally had no staff and only a skeleton organization. IDA was <u>in</u> government quarters and acted like government and even worked with visiting contractors <u>as</u> government. That, of course, caused the worry.

General Betts' year as ARPA Director was to spell the beginning of the end of IDA's role as a shaper of ARPA programs. This came about as the culmination of several developments. First, the decision to transfer ARPA's space programs and ARPA's reorientation toward basic research removed much of the impetus of urgency on which the case for tapping experts on leave from private industry was largely based. Second, the space transfers meant that much of the expertise provided by IDA was no longer required by ARPA, so that it was relatively easy to phase down IDA support and to hire civil service staff directly in ARPA's new assignment areas where IDA had been less intimately involved in program development. Third, a number of factors combined to make IDA less interested in continuing to be a pervasive force within ARPA, e.g., the vulnerability of the arrangement to Congressional and other outside criticism (which had long concerned the IDA Board), the decreased status of the ARPA program, and increased tension between ARPA's new technical staff and IDA's expert consultants. The Critchfield incident which preceded Betts' appointment was perhaps also symbolic of decreased Congressional and public acceptance of blurred distinctions between governmental employees and industrial contractors. IDA itself was changing in the direction of greater institutionalization and staff permanency and less willingness to accept the kind of ad hoc ill-defined arrangements characteristic of its early role in ARPA. Finally, ways and means were being found to bring scientific and technical talent into government at higher pay scales.

As a result of the above trends, the Betts period moved strongly in the direction of limiting IDA's role in ARPA program management. On the issue of governmental control, a Betts memorandum to the staff on March 9, 1960 reaffirmed and strengthened the authority of the Program Council (revising and expanding procedures for processing matters through the Council) and provided for a civil servant project manager (or project team) to be designated by TOD for each approved work effort, thus establishing government employee counterparts wherever IDA people might be involved.[44] Perhaps most important, however, was the previously described decision to reorganize the ARPA staff by eliminating the comprehensive Technical Operations Division and creating offices for each major program area. Creation of these offices, each to be headed by a relatively high salaried technical director, provided the basis for upgrading ARPA's thin internal technical expertise. As Betts noted, "these Assistant Directors will have extremely broad authority both for technical program planning and proposal evaluation as well as day-to-day technical project management."[45] As part of the reorganization, the IDA contract was revised to eliminate the "Advanced Research Projects Division" and to replace it with a "Research and Engineering Support Group," to be "concerned primarily with the analysis of relevant areas of science and technology in order to recommend emphasis in research and development, rather than ... detailed technical planning and proposal evaluation...."[46]

Finally, ARPA staffing plans were drastically revised during the middle of Betts' term in order to increase the government staff. Early in the year, ARPA projected a staffing level of 90 individuals (both professional and support staff), and indicated about 100 individuals (professional and support) would supplement the effort through the IDA contract. In July in memoranda involving Deputy Secretary Douglas and Dr. York, the ARPA staff level was upgraded by 27 positions (an increase of almost one-third), and IDA's "gradual disengagement" was endorsed by York.[47]

By the end of General Betts' year as ARPA Director, IDA was well on its way to being reduced to the more traditional contractor role of producing specific studies, technical analyses and advice and the basis was laid for the development of strong technical management within ARPA proper.

The transition, however, did not occur smoothly. DEFENDER, the largest continuing program, was highly reliant on IDA personnel and the shift to civil service staffing (including transfer of some IDA staff to civil service appointments) was difficult. The first civil service head of DEFENDER felt that the rupture with IDA was too disorderly and probably came too soon, and recalls having to hand out IDA-prepared program files to newly recruited ARPA staff without having any feel for their contents.[48] The considerable dissatisfaction with DEFENDER expressed by Dr. Ruina when he arrived at ARPA in 1961 was probably generated to a considerable extent by the crisis in transition from IDA.

On IDA's part, the twin "demotions" represented by ARPA's loss of its highest priority programs and IDA's reduced role within ARPA was met with some dismay. Early in the Betts period, IDA endeavored to move toward a more direct (including contractual) relationship with the higher echelons, as represented by DDR&E. This was resisted by ARPA, which resented IDA's search for a more "prestigious home." General Betts complained to Dr. York that "the single most serious problem I have had to contend with since becoming Director of ARPA .... lies in the fact that individual IDA employees do not desire to be scientific advisors; they desire to be and act as technical project engineers;"[49] and he implicitly attributes IDA's overtures to DDR&E to a desire to continue these ambitions. In fact, the major DOD contract with IDA (excluding WSEG) was continued through ARPA, but it later came to be regarded by many in ARPA as simply a DDR&E funding channel and a "tax" on the agency.

Many IDA staff in ARPA were dead set against being removed from the Agency, fearing that a more "normal" government organization would fail. In retrospect, however, one of them concedes that "Government people were better at carrying out a program than we were, once it was put together; we only were able to get things done because we were new and people were afraid to get in the way of the machinery, but that wouldn't have lasted."[50] It did not.

Over the years the IDA contribution to ARPA, while remaining important in numerous specific areas, was to become less and less central to the Agency. In late 1969, an ARPA review of IDA cites a feeling of remoteness from DOD decision-making at IDA and a DDR&E/ARPA sentiment that IDA "can't or won't provide help when needed."[51] IDA's avoidance of any arrangement which could be considered "personal services" amounted almost to a "phobia," a far cry from the space days. The IDA staff is described as "a rather mixed group in terms of breadth and depth" and deficient in quality in numerous areas. Despite a defense of the rather unique continuing arrangements enjoyed by IDA vis-a-vis ARPA and DDR&E, the review concludes that "regarding the uniqueness of the skills at IDA, the simple fact is that there aren't any." Thus, the very special role played by IDA prior to 1960 is significantly reduced by the changes in General Betts' tenure and continues to move in the direction of a more normal contractor's role in following years, albeit a contractor with a particularly close association with ODDR&E and ARPA.

<u>Program Council</u>. In addition to previous comments on the Program Council in the context of ARPA organization and the IDA relationship, a few remarks on the significance of the Council in the early ARPA years are appropriate. For three or four years following the Council's creation in early 1959, the group's role was extremely important in the management of ARPA's R&D program. Its influence during these years, and particularly during the Betts period, is difficult to exaggerate.

The main items brought before the Council were IDA "Technical Evaluations" (which assessed proposals in terms of rationale, extent of duplication with other work, priority, and complementarity to the overall program), development and funding plans required to initiate ARPA Orders, and special contract and procurement matters. Very importantly, the composition of the Council (aside from the Chief Scientist) was non-technical in character and thus provided a source of administrative and policy review for every new ARPA initiative. While the Council only provided recommendations to the Director, it was heavily relied on by Johnson for more detailed review of space projects and for non-space projects in general, and was even more thoroughly depended upon by General Betts as "the mechanism by which ... [he and others in ARPA management] kept in touch with what these other guys were doing."[52] Betts remembers it not so much as a positive "decision tool" but as a vehicle by which to control the program in a budgetary sense and otherwise, this in an atmosphere of constant pressure for new initiatives in a wide variety of fields.

To illustrate the permeating restraining influence of the Council, of fifteen items brought to it for approval at its very first meeting only six were given full approval with a recommendation for the Director to sign-off, seven were referred to other parts of ARPA or to IDA for further work or revision, and two were simply deferred for later Council consideration. This ratio of approvals appears quite representative of Council actions over the years (the last 1959 session, for example, considered an item originally submitted in April), so that the Council clearly did not simply rubber stamp IDA and ARPA staff proposals. According to a contemporary staff member, this careful review process was absolutely necessary at the time, with many ill-considered proposals being generated ("many of the technical write-ups made you throw-up"); moreover the technically-oriented ARPA/IDA staff often was quite deficient in considering legal, budgetary and other non-technical questions.[53] Without the Council, he felt, the Agency would have pulled many serious gaffes.

From the position of the technical staff, the Council was, of course, typically viewed as a nay-sayer and bitter battles were fought on many issues. Efforts were constantly made to appeal around the Council to the Director, Deputy Director, or Chief Scientist. As long as the technical program advocates were primarily contract employees housed in IDA, however, the need for a clear official government stamp on programs was obvious and the Council was the central mechanism by which that essential function was performed.

This reinforcement of the Council's position began to break down late in the Betts period with the upgrading of ARPA's internal technical capabilities and decreased reliance on IDA. When a series of technical offices within ARPA was finally established in the latter half of Betts' year a base was laid from which the Council could be more vigorously and persuasively attacked. As will be discussed below, Betts' successor was highly oriented toward substantive technical issues and preferred to rely on his technical staff rather than the more administratively-oriented Council members. With the technical office directors now able to argue that they too represented the government and could adequately consider administrative issues, the role of the Council declined. After many heated disputes and efforts to save the Council it was eventually abolished and its functions internalized within the technical offices or incorporated into the annual cycle of budget review activities.

Executive Agents. The executive agent system was working, but not well, when Betts arrived. General Ostrander told him that there was a six month backlog in execution of ARPA work and Betts soon verified it:[54]

> [T]hat was probably the single most discouraging part of the whole job. In all justice, I think Larry [Gise] and I and Bill Godel knew that we shouldn't try to duplicate the Services' ability to let contracts and manage problems and yet it was most discouraging to go through the drill of working up proposals ... putting something together that was responsive to what we were trying to accomplish ... and write the ARPA Order to one of the Services to please do this and carry it through, and nothing would happen.

Betts personally visited many of ARPA's agents to beg for assistance. The response, he said, was often "great lip service," but "those things used to sit months on somebody's desk because he was doing his own work first, and then he would get around to the ARPA work when it was convenient. It was a fundamental problem." Ruina, too, was to feel frustrated by administrative delays and red tape.

ARPA often called on OSD's tiny procurement office to let contracts with very tight time constraints, but this relief was limited by the workload the office could sustain and by the fact that it had no capability for technical monitoring of work.

PROGRAMS IN THE BETTS PERIOD

The ARPA program folio during the Betts period was a mixture of space era survivors, late 1959 initiatives and new, small (if not almost trivial) DDR&E assignments. In addition, the first half of Betts' tenure was to a considerable extent devoted to clearing out miscellaneous space projects that had earlier been marked for transfer. These residual projects in process of transfer are not described in the following pages, but it should be reiterated that a major part of the Betts mission was to close the books on the space period. Notable transfers included the Navy navigation satellite and the Army communications satellite programs (both gone by mid-year) and the satellite tracking network.*

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* ARPA funding ceased on June 30, 1960, but it retained management responsibility for the tracking network until November 30, making it the last of the space projects to be transferred.

Even aside from the "lame duck" space projects, the program mix in the Betts year is the least conceptually rationalized in ARPA's history and unifying themes are most difficult to find. Program assignments ranged in size from the $100 million DEFENDER program to the under-$1 million level, e.g., the reliability program. New assignments ranged in priority from VELA, an urgent national requirement growing out of test ban negotiations, to the TORES assignment, where the primary problem was to find a convenient way to fund a modest Army chemical laboratory project. Projects came from outside DOD, the DDR&E, IDA staff recommendations, internal ARPA planning, unsolicited contractor proposals, and the Services. While much of this diversity continued into later periods, what is lacking in the Betts period is a clear sense of direction and program philosophy.

This picture of a rather disorganized and nondirected program derives partially from the attention still being given to liquidation of the last of the space projects and from the extensive internal reorganization taking place throughout the Betts year. Perhaps most important, however, was the basic fact that General Betts did not seek to run the agency and its programs according to some set of abstract principles and did not become an aggressive advocate for any particular element of the ARPA program. As previously cited, Betts saw ARPA's role as serving the DDR&E by providing a home for whatever research and development activities the DDR&E felt required central management at the OSD level. In 1960, the DDR&E's requirements in this regard were modest and did not reflect any clear philosophy as to the continued role of the agency. The FY 1961 budget was less than half the previous year's level and over 80 per cent of it was accounted for by DEFENDER and hold-over space projects scheduled for transfer (see Figure IV-1).

DEFENDER

The DEFENDER program during the Betts period was, as it continued to be for many years, a $100 million program. While Betts was Director it amounted to well over half the ARPA budget, exclusive of the outgoing space projects.

Charitably speaking, the DEFENDER program inherited by Betts was quite chaotic and, if anything, became more so in 1960 due to the difficulties in shifting from heavy dependence on IDA consultants to internal staff. By mid-year the effort was divided into six technical branches which were carried over into the Ruina directorship which followed and are described in the chapter dealing with programs of that period. The activities within these branches were often an odd lot, however, an example being the General Research branch, which included basic research in atomic and molecular physics, building an atmospheric observatory/radio telescope in Puerto Rico, nuclear effects research in collaboration with the Defense Atomic Support Agency, development of the first large phased array radar

Figure IV-1

PROGRAM BUDGET HISTORY DURING THE BETTS PERIOD
($ millions)

	FY 1960	FY 1961
Appropriations Request	455	215
Actual budget	455[1]	215
Commitments To Agents	276[2]	207
Requests By Program:		
Space/Satellites	307[1]	67[3]
DEFENDER	128	110
VELA	- [4]	- [5]
Propellants	18	17
Materials	- [6]	17
Administration	2	-

1 Approximately $200 million of this amount transferred to Services.

2 Figure inconsistent with above due to transfers.

3 Transferred to Services during year.

4 Approximately $8 million was budgeted on VELA from emergency funds/reprogramming.

5 Approximately $40 million for VELA later added to initial ARPA request.

6 Materials initiated with DOD emergency funds (approximately $17 million, FY 1960).

Source: ARPA budget tables.

(the Electronically Steerable Array Radar, ESAR), research on BMD data processing requirements, and building high power radar transmitting tubes. The rather casual branch structure probably traces back to the earlier, somewhat arbitrary, division of the DEFENDER program among various IDA staff members.

The outstanding features of the DEFENDER program during the Betts period were: (1) a very extensive radar and radar components development effort, and (2) a multi-faceted program relating to measurement of the signatures of re-entry vehicles and associated development of techniques for detecting and discriminating among such bodies. Both of these research areas were to remain of dominant importance in the DEFENDER program for many years and there were numerous achievements in both areas by 1960. At the time, however, each had important problems. The radar program, for example, was quite diffuse and probably attempted to cover too broad a front; considerably greater focus was given this program in the Ruina period. In addition, there were some expensive dead ends in radar development. The most notable example probably was the so-called PINCUSHION radar, which was cancelled in the early 1960's after a sizable investment over several years (at least $16 million). In the reentry measurements area, the primary difficulty was that the effort was hobbling along with inadequate facilities, instrumentation radars and other equipment. This gave rise to the most far-reaching DEFENDER development in the Betts period, development of the Pacific Range Electromagnetic Signature Study (PRESS) described in greater detail below.

Despite solid developments in both of the above areas, the generally perceived flavor of the 1960 DEFENDEP program came to a considerable extent from the series of systems studies, preliminary investigations and concept development efforts which pointed toward exotic solutions to the ballistic missile defense problem. A number of these efforts were widely publicized and together they gave the DEFENDER program a slightly flaky, if not outright bizarre sort of image. Among them were the just-completed GLIPAR (Guideline Identification Program for Anti-missile Research) program, the results of which were just being circulated by 1960. A $1.6 million study effort, GLIPAR funded twelve contractors to examine the feasibility of the most remote sorts of technological breakthroughs that could conceivably have ABM applications.[55] Justified on the grounds that even the mostly remotely plausible technological applications should be thoroughly reviewed in order to see that nothing which could possibly lead to a disastrous Soviet breakthrough was overlooked, science fiction concepts such as magnetic barriers and anti-gravitation devices were examined and rejected. No systems work ever emerged out of GLIPAR, but certainly nothing had been overlooked.

Even so, ARPA did proceed further with several far-fetched concepts. One program, called SAMBO, envisioned a shield of small pellets (or bee-bees) in orbit, a concept eventually rejected due to the enormous volume of material which would have to be launched into orbit at astronomical costs. An even more seriously pursued concept was BAMBI (Ballistic Missile Boost Intercept), a satellite-based ABM concept with several variations, all of which involved detection of hostile missiles at launch and the dispatch of intercepting missiles from satellites (the number of interceptors, kind of "kill mechanisms," etc. differing from version to version). This system concept, as previously noted, was inherited by ARPA from the Air Force and was promoted by the Air Force and its contractors. ARPA is credited by some observers with killing the concept (in the Ruina period), thus heading off Air Force pressures for proceeding toward systems development, but it is criticized by others for carrying the project beyond the point when it could have been clearly rejected on cost-effectiveness grounds.

In addition to the above concepts, ARPA carried projects looking at such exotic ABM measures as nuclear "cannons," launch of randomly distributed pellets or flechettes for terminal phase intercept, and early laser and charged particle beam concepts. The "billion dollar budget" of the Roy Johnson period, discussed above, briefly carried a $300 million per year estimate for the particle beam and its "death radar sub-system."[56] The particle beam was a creation of N. Christofilos, a brilliant and eccentric thinker who seemed to be able to mesmerize fellow physicists. Few could bring themselves to turn down his ideas and it is hard to fault ARPA for supporting some of them. York's description of Christofilos is characteristic of several we received:[57]

> Nick was a remarkable idea man. The ideas were usually not good, but they were really remarkable in that they were the kind of ideas that nobody else had. Nick really was a genius in a very important sense -- he often invented things that required two new ideas simultaneously, which is something that normally, hardly anybody ever does.*

Some of these exotic concepts carried on well into the 1960's, and laser weapons research continues in ARPA and in the Services today, having gained respectability following breakthroughs in laser power output in the mid-1960's. The point to be made here, however, is that exotic approaches to ballistic missile defense were much more prominent in the 1960 DEFENDER program than they have ever been since. For those observers skeptical of a revolutionary breakthrough in such exotic approaches, the ARPA program appeared rather shaky.

Perhaps Holbrook's assessment is fair. Asked by Godel to evaluate the BMD program before he left ARPD/IDA in the fall of 1959 because 'we

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* One of Christofilos' "not good" ideas was to build a large aircraft runway across the entire U.S., coast to coast, so that the Soviets could never catch most of the SAC aircraft on the ground at the same time.

can see your trees, but no roots; what have you done for $110 million, and why?', Holbrook, in essence, stated: "What we did was 50 per cent crap and 50 per cent good stuff, and that ain't bad, given the circumstances."[58]

PRESS. During the Roy Johnson period the ARPA BMD program had initiated a series of reentry measurements projects. These included a joint program conducted with NACA at Wallops Island on the Virginia coast (where measurements were made for both BMD and space vehicle development purposes), and a ship-borne radar measurements program, notably the so-called DAMP ship.* The latter was an expensive proposition which was unlikely to be undertaken by the Services during a time of tight Eisenhower budgets and great emphasis on hardware development, but it provided some of the first missile warhead "head-on" reentry measurements data of respectable quality and thus contributed to reentry vehicle design and offensive-defensive missile systems concepts. It also helped confirm the value of taking the time to obtain hard technical information before commiting to vast, expensive systems design and development exercises against a vaguely understood threat.

The 1958-59 program was, however, only an immediate response to pressing post-Sputnik requirements, and the Wallops Island facility, the DAMP ship and other projects clearly had severe limitations. As one respondent noted, reentry measurements work was still in a "primitive state," utilizing a number of "hit or miss" techniques.[59] Consequently during the Johnson period considerable support developed for a major reentry measurements facility, utilizing specially designed radars and other up-to-date equipment. There was extended debate about the organization of such a facility and where it should be located, well into the Betts period.

Under General Betts' directorship, interest in a new reentry measurements facility coalesced around the concept of a major ARPA program located on the Pacific Missile Range, where the Army's NIKE-ZEUS effort was beginning to enter the hardware testing phase. The ZEUS program, however, did not have adequate reentry measurement radars; that is, the radars were not designed to provide detailed data on reentry characteristics. It was therefore felt that an appropriately located ARPA program could "piggy-back" the NIKE-ZEUS tests, i.e., use the NIKE-ZEUS firings as target vehicles for its own purposes, while providing useful feedback to the Army's development program. This program concept quickly came to be called PRESS (for Pacific Range Electromagnetic Signature Study). The PRESS idea was discussed extensively at mid-year and Lincoln Laboratory, the major contractor for the Wallops Island program, was asked to evaluate the concept. In August 1960, Lincoln's report enthusiastically endorsed the project and recommended that

* DAMP was an acronym for Downrange Anti-Missile Measurements Program. Some $40 million was spent under the DAMP ARPA Order over the years, though a considerable portion of this contributed broadly to ARPA's overall reentry measurements effort.

the effort be placed under the unified management of a single contractor.[60] Dr. York approved PRESS in the same month and shortly thereafter Lincoln Laboratory was asked to accept the role of "scientific director," thus filling the central management role Lincoln itself had deemed necessary.

The impetus behind PRESS appears to have derived from a deep-seated feeling in ARPA and OSD that a basic lack of understanding of the physical and chemical phenomena involved in missile reentry was a major limitation in BMD development. Absent such information, the potential performance of ABM systems against incoming missiles of varying design, possibly accompanied by decoys and penetration aids, was simply unpredictable.[61] Dr. York (who had been instrumental in bringing Lincoln into the earlier reentry physics program) repeatedly emphasized, as DDR&E, the need to know the state of the art rather than relying on "new trick methods" as a solution to the BMD problem. Conversely, he was critical of DEFENDER's early emphasis on exotic BMD concepts.

The Army, it was felt, was not prepared to undertake the task of expanding reentry measurements capabilities across a broad front. Dr. Ruina, on the DDR&E staff at the time PRESS was approved, stated that "the Army only had interest in developing a system for procurement.... 'The Army has no interest in research' ... [an Army General] said in an open meeting or speech, ... 'we're just defending America -- and all this measurement and stuff is [horsefeathers].'"[62] A Lincoln Laboratory spokesman involved in PRESS also stressed that the Army was not research oriented and would not support a major experimental program, and that it therefore took a "big, bold" decision on ARPA's part to initiate the program.[63]

The Army's hostility to a broad measurements program obviously related to the fact that such an effort, by emphasizing the unknowns concerning reentry phenomena, reflected a cautious attitude toward solidifying BMD concepts into an operational system ready for procurement, at a time when the Army was pressing hard for NIKE-ZEUS development. Creation of PRESS thus represented something of a victory for the forces taking a cautious attitude toward development, and the output of PRESS, which tended in the immediately following years to highlight problems in discrimination of warheads in ZEUS-type systems, did come to provide a technical foundation for such a conservative approach. As York remembers, "it's probably true that much of the scientific and technological basis of the arguments against ZEUS actually came out of there [DEFENDER]," and PRESS became the most prominent vehicle through which such technical objections were developed.[64]

The initiation of the PRESS program during the Betts period was thus an undertaking begun without Service support, made possible by the DDR&E's interest and concurrence. During the Ruina directorship, PRESS became the core program of the DEFENDER effort and continued in that role until DEFENDER was eventually transferred to the Army in 1967.

<u>Phased Array Radar</u>. In November 1960, just prior to General Betts' departure, the first full-scale prototype of the Electronically Steerable Array Radar (ESAR) was completed and put "on the air." Inherited from the defunct Air Force BMD program, the ESAR was the first sophisticated phased array radar and it had an enormous impact on military radar technology. It gave birth to both a direct Air Force follow-on radar (the SPADATS F-85, produced by Bendix, the ESAR contractor) and established the technological basis for the phased array radars incorporated into the Army's Nike-X/Sentinel/Safeguard system. ESAR is consistently listed among the top ten or so contributions to military technology developed by ARPA over its entire history.

ARPA's role in the development of phased arrays through the ESAR program may perhaps best be described as that of providing steadfast support to a highly uncertain technology at a time when strong Service support was quite unlikely. The program was not conceived in ARPA, but only ARPA was willing and able to "stay the course" through the late 1950's and early 1960's in order to demonstrate that the phased array concept was a practical radar technology. The Air Force, deprived of a BMD mission, would have had great difficulty in providing internal justification for the program (the phased array's primary virtue is its ability to observe multiple objects, a special requirement of BMD systems). On the other hand, the contemporary Army BMD program (including its prime contractor, Bell Telephone Laboratories) was wedded to the elaborate mechanically steered radars of the NIKE-ZEUS program, in which it had a considerable investment and continuing hopes for near-term deployment. For that matter, Lincoln Laboratories and ODDR&E were also opposed to phased arrays. Thus ARPA played a classic role in this instance by pursuing exploratory development of ESAR despite negative opinion and an obvious high risk of failure.

ESAR's major contribution, which started to become clear shortly after Betts' departure, is succinctly summarized by Dr. Ruina in Congressional testimony:[65]

> This radar [ESAR] has successfully demonstrated that one can control the beam of a radar electronically and yet accurately, rather than by swinging a dish mechanically. This makes the beam much more agile thereby making it possible to observe many targets almost simultaneously. It is fair to say that this demonstration has changed radically all thinking about AICBM radars and that all systems presently considered, including Nike-X, depend heavily on the use of phased arrays ... when the program started there was a great deal of doubt that it was really an important one and achievable. Now, it is ... an accepted part of the technical community....

Despite the turbulance of the Johnson period and the organizational uncertainty of the Betts year, phased array radar research was steadily supported. The success of the ESAR program was founded on developments during this period.

VELA

The foundations for the VELA nuclear test detection program were laid during Roy Johnson's second year in ARPA, and a small amount of initial funding was provided for the program in September 1959. This was a major assignment dealing with an issue of national importance and it took some time to shape the ARPA program. The program was formally assigned to ARPA as a part of the new December 30, 1959 ARPA Directive, just after Betts became Director. Public announcement of the VELA program was not actually made until the spring of the following year.

For a clear picture of how the VELA program came into existence, it is helpful to understand the series of events which first established the need to improve nuclear detection capabilities. The need was not always apparent when early test ban negotiations were being conducted in the 1950's. At the 1958 Geneva Conference of Experts, for instance, scientists perceived very few problems relating to the detection of nuclear tests. Basing their position on this technical assessment, they devised a relatively simple scheme for monitoring a proposed test ban.[66] The viability of this scheme -- what had come to be known as the Geneva Plan -- was soon destroyed, however, when new scientific data revealed glaring weaknesses in our nuclear detection capabilities. The results of Project ARGUS and the Johnson Island shots during July and August 1958 illustrated the difficulties of high altitude test detection,[67] and the Hardtack Series in September highlighted problems connected with underground test detection.[68]

Recognizing that these technical deficiencies would slow up test ban negotiations, the U.S. government sought to improve its nuclear test detection capabilities and to make the Geneva Plan operative once again. Responding to a State Department suggestion, the President's Special Assistant for Science and Technology, Dr. Killian, appointed a committee on December 28, 1958 to study the problems involved in underground detection (the Panel on Seismic Improvements, better known as the Berkner Panel);[69] somewhat earlier, a group under the direction of Dr. W. Panofsky had studied the difficulties of high altitude test detection.[70]

Both groups issued reports which concluded with statements to the effect that intensive research programs were needed in their respective areas. On April 23, 1959, Dr. Killian, AEC Chairman McCone, and Deputy Secretary of Defense Quarles met to discuss the recommendations of the Berkner and Panofsky Panels, and decided that the responsibility for implementing the recommended research programs would be handed to the Department of Defense, with support from the AEC and NASA.[71] Lewis Strauss and others at AEC were bitterly opposed to any restrictions on testing and placing responsibility there was out of the question. As neutral as York was about the ARPA device, this was probably one time when he was happy to have it handy. He felt strongly about the nuclear test moratorium:[72]

> I remember playing a major role, to exaggerate perhaps and boast about it. I feel that it was Kistiakowsky and I who personally kept the moratorium going in 1959 and 1960 because he in the White House and I in the Defense Department kept knocking down all the claims coming in from elsewhere about how we <u>had</u> to start testing and about how the Russians <u>are</u> testing.

Test ban opponents were constantly producing reasons why testing was crucial. The existence of an ARPA, under the DDR&E's control, was probably essential.

In the next few months, various advisory groups within DOD began preliminary studies to lay the groundwork for formal research proposals. Such proposals were drawn up by the Air Force office which had operational responsibilities in the nuclear test detection area, and in August 1959 several supervisory groups were established within DOD. On September 2, 1959 the Secretary of Defense assigned actual responsibility for overseeing this research to ARPA.[73] Moving with its customary quickness, the first VELA work order was issued one month later, in October 1959. By mid-April 1960, T. W. Brundage of the Policy and Planning Division had completed a survey of European skills and resources and reported widespread interest, capability and willingness there to participate in seismic research. The first public announcement of the VELA assignment was made on May 7, 1960.[74]

Presidential interest in the VELA assignment was very keen. Kistiakowsky impressed on all those concerned that the President personally considered VELA a high priority program, and that he intended that it be directed to improving of our capability to detect and not just to defining the technical limitations on detecting. The President was especially interested in what the VELA program might achieve, particularly the prospects for inventing unmanned stations. The State Department stressed that the President fully supported the concept of an open and truly cooperative program, i.e., the Soviets would be permitted to see the results. The U.S. wanted to be able to show that it was making a massive effort to find the right answers. To underscore White House concern, Kistiakowsky claimed that he had a charter to look at VELA program administration to clear-up any possible bottlenecks,*

* Personal recollections of Lt. General A. W. Betts of a meeting that took place April 7, 1960. Among the attendees: Kistiakowsky, Panofsky, Philip Farley (State), Spurgeon Keeny (Science Advisers office), Betts and C. Beyer of ARPA, General Starbird, and Messrs. Latter, Ewing, Press and Tukey. (Discussion with General Betts, April 7, 1975.)

perhaps a thinly veiled message to the Air Force and ARPA to bury the bureaucratic hatchet and get on with the job. ARPA had been selected for the job in part because it had shown ability to handle interdepartmental programs, but "the problem with it was that by that time we had lost all of our interdepartmental clout."[75] ARPA was frequently to feel constrained by lack of power in its long association with this program.

The initial VELA assignment involved seven tasks, all directly related to issues and concerns growing out of the test ban negotiations. The first task was to create a worldwide network of standardized seismographic stations through an equipment upgrading program, this network intended to greatly increase research capabilities in seismology around the world as well as to improve nuclear test detection capabilities in a rather loosely-organized manner (the network was not a formal international test detection system). The second task was a wide-ranging charter to conduct research relating to underground test detection, which became the basis for VELA Uniform, the largest VELA office for many years. The third task called for research on seismic detection stations, to test and improve the so-called "Geneva-type" stations which had been recommended by the Geneva Conference of Experts as the core of an international detection system, but about which U.S. experts had come to hold considerable doubts. The fourth task involved nuclear and chemical underground tests designed to expand current knowledge about the seismic signatures (and hence potential detectability) of tests. The three remaining tasks called for the establishment of a VELA information center to serve as a central point for the collection, analysis and dissemination of seismic data; for ad hoc research support as required by the Geneva negotiations; and for research on "on-site" inspection techniques.

Obviously the initial VELA tasks varied considerably in specificity and scope. As most of the tasks related to underground testing, they later became component efforts of VELA Uniform, the general program of underground nuclear test detection research. On-site inspection research was continued separately, sometimes as a sub-office of VELA and sometimes as part of a larger office, depending on the fluctuating priority of the task over the years.

The initial emphasis on underground test detection in part grew out of the conclusions of contemporary experts that this form of testing provided more serious questions of detectability than atmospheric or even outer space testing, and in part because the initial program plans were drawn up by the DOD agency primarily concerned with underground test detection. Even before 1959 came to a close, however, and throughout 1960, ARPA endeavored to broaden the VELA mission through the addition of research on surface-based and satellite-based means of detecting atmospheric and outer space tests (this interest supported by the previously mentioned Panofsky Panel). Satellite-based detection systems, in particular, were subject to considerable debate on cost effectiveness grounds and it was not until the end of Betts' year as Director that a modest satellite research program (named VELA Hotel) was approved by the Secretary. York and Betts were suspicious of some still-active "space cadets" who proposed rather wild programs. Both men felt it would be exceptionally costly to monitor "outer space" and they believed that nobody really expected the Soviets to test there anyway. York sums it up as follows:[76]

> The two things I was specifically opposed to were: first, what I regarded as gross underestimates of the cost of the space system (there were people like the Latter brothers at RAND, and others, who kept saying 'it's very simple and cheap' and I kept saying 'it's <u>not</u> simple and it's <u>not</u> cheap') and second, there were the people who were saying they can test on the back of the moon and can test behind the sun (there were all these grotesque ideas about how the Russians would cheat), and I ended up arguing, believing and claiming that those were ideas that were basically nonsense. The Russians weren't going ... it's not practical to test behind the sun or behind the moon. You don't have to have VELA with all that capability, so I did react negatively with respect all kinds of excesses, to what I regarded as excessive notions about VELA.

As will be noted in the Ruina and Sproull program discussions (particularly the latter), the satellite effort was ultimately to become one of the great VELA success stories, confirming that it indeed was simple and cheap to use satellite detection capabilities.

<u>Materials Research</u>

During the Betts period the Materials office moved to implement the broad charter granted the preceding year. Numerous questions remained concerning the long-term organization and scope of the effort, particularly the scope of ARPA's Interdisciplinary Laboratory (IDL) program as compared with the IDL programs to be initiated by NASA and the AEC. Consequently a great deal of emphasis in the Betts year was placed on resolving organizational and program planning issues.

There were, however, significant accomplishments. For example, initiation of the "quick response" materials equipment grant program was carried out. Designed to upgrade the physical capabilities of universities rapidly to conduct materials research, this program granted approximately $3 million to some 56 universities in FY 1960 (and a similar sum in FY 1961) for purchase of laboratory equipment.[77] Although the grant program extended beyond 1960, the impact of this initial funding was clearly most significant. Aside from its direct effect on university programs, it alerted schools across the country to a major new source of long-term research support and contributed to awareness of the substantial support which would be provided to universities through the IDL program. Partially as a result of the contacts resulting from the equipment grant program, ARPA was practically overwhelmed with proposals for IDL's.

ARPA moved forward rather slowly with the IDL program. The burden of evaluating proposals, uncertainties over the ultimate scope of the program and the desirability of spreading start-up costs over several years undoubtedly contributed to this approach. Only three IDL contracts were granted as of June 1960 (Cornell, Northwestern and the University of Pennsylvania). Planning then began for a second round of selection which was to be completed in Dr. Ruina's first year. In the end, the ARPA IDL program was to reach a total of twelve universities and dwarf the IDL commitments of the AEC and NASA.

Obviously there was little or no output from the materials projects during this period of organization and investment; however, many of the basic features of the Materials program were firmly established for years to come. The first three IDL's, for example, were given four-year contracts, i.e., funding in the current year and for three "forward" years. These future guarantees were maintained through the late 1960's at a constant level by adding a subsequent year of funding each year. The same procedure was followed for the nine IDL's subsequently selected. A second major feature of the first IDL contracts, also copied for the later IDL's, was the insertion of a "use charge provision" by which ARPA committed itself to repay over a ten-year period university costs for additional space, land acquisition and finance charges generated by the IDL's. The "use charges" and forward funding commitments together assured a rather heavy ARPA involvement in university materials research for years to come.

Betts was a strong supporter of the IDL program. He knew that York had been instrumental in creating the program and he concurred, because "all our problems sooner or later came back to the difficulty of materials and we really ought to spark a major effort to create a stronger technology base in materials."[78] Betts' only regret is that he did not have more money to put into the program. He feels that just when its momentum had built up in the late 1960's, it was hurt by withdrawal of Congressional support: "that Materials Program never did get the support it could have used, and in my judgment would have been effectively used."[79]

<u>Propellant Chemistry</u>

Propellant chemistry research was the third largest ARPA program in 1960, following DEFENDER and the newly-assigned VELA project. It was funded at a level of some $18 million per year and was the second oldest program in ARPA, having been assigned in June 1958, following the

Kistiakowsky survey. It was, in a sense, a holdover from ARPA's space mission, since the requirement for propellants with higher useful energy outputs was derived from space vehicle and missile needs. The project was, in fact, described as "space vehicle/missile advanced propellant chemistry" as late as November 1960, when a revised enclosure was provided for attachment to the ARPA Directive.[80]

ARPA research in this field was proceeding very slowly in 1960. In the ARPA Semi-Annual Report of September 1960, the work was described, in part, as follows:[81]

> Technical progress has been difficult due to the extremely complicated nature of the research. Great difficulty is being experienced in new oxidizer synthesis areas. Fuel synthesis research on aluminum hydride has also been shifted to other areas because of the problems concerning purity and instability....
>
> Research in other areas including thermodynamics, combustion, nozzle cooling, high temperature, detonations, and non-destructive testing is progressing slowly but with continued enthusiasm....
>
> Technical progress toward achieving the objective has been difficult. A few promising avenues are being opened up and a few unrewarding avenues have been brought to a close. Of greatest hope in the field of oxidizers is the synthesis of new compounds containing the NF group. These compounds promise to impart high energy when mixed with the proper fuel. Other useful oxidizers which are in the limelight are hydrazinum nitroformate and nitronium perchlorate. Research continues on the chemistry of interhalides, of compounds, and superoxides....
>
> Research on aluminum hydride has been directed along more promising lines after it was concluded that this material could not be prepared either pure or stable. Boron hydrides remain of great interest in combination with NH type compounds to form boron nitride and hydrogen. A definitive answer to combustion efficiency problems should be forthcoming.

Reflecting the difficulties encountered, the solid propellants effort is described less and less in terms of attaining dramatic breakthroughs in the specific impulse of fuels, and more in terms of long-term developments and incremental contributions. General Betts' statement before the House Appropriations Committee in 1960 is illustrative:[82]

> I think that some of the new propellants we are talking about in the ARPA program have little likelihood of getting into actual usage in something short of about 5 years, but I am not sure that there are not intermediate steps in terms of application of things already being done in solid propellants that may succeed in getting a propellant to the point where it would upgrade the POLARIS in 3, 4, or 5 years. But, it is not a tomorrow proposition.

Also in recognition of the problems and limitations in solid propellants per se, the charter of the ARPA office is extended beyond solids to include research in hybrid and certain liquid propellants in November 1960.

Thus while the propellants project was generated in the post-Sputnik crisis atmosphere, amid hopes for major early breakthroughs, by 1960 the project had taken on much of the flavor of long-term research support. In this regard it appears somewhat akin to the newer materials program, and is clearly of secondary importance to DEFENDER and VELA.

JASON

The JASON program also originated in ARPA during the Betts period as one of the many smaller assignments given ARPA at that time. Assigned to ARPA under the soon-abandoned title of Project SUNRISE, the JASON group (for which name there are multiple colorful explanations) was to be a small (30-40 man) aggregation of especially brilliant young scientists, who would undertake:[83]

> Study of basic defense research problems; identification of basic research problems which are vital to national defense and which are not now receiving adequate attention in the scientific community; making contributions of a conceptual nature toward solution of Department of Defense technical problems; advice regarding scientific developments on which projects might be initiated which would enhance national security; and preliminary studies and analyses to examine the feasibility of new ideas and concepts.

The JASON concept actually originated in 1958 with a conference known as Project 137, involving (among others) economist Oskar Morgenstern and physicists Eugene Wigner and John Wheeler, which was designed to familiarize a group of younger physicists, most of whom had worked in summer study groups at Los Alamos, with other high level military technology problems. Underlying the rationale for the conference was the concern that the DOD was relying too heavily on the last generation of scientists for advice (particularly on those associated with atomic bomb development) and that the current missile-space crisis highlighted the need to tap the best young scientists as well. Wheeler, considered by Dr. York to be the most important figure behind the concept, was particularly persuasive as to the need to inject more scientific thinking into national security problems and in a fashion that insured a close connection to top policy levels.[84] In the following year members of the Project 137 group (two additional key individuals being Marvin Goldberger and Marvin Stern) met in a second conference, out of which the case was made to establish the panel of young scientists on a permanent basis. DDR&E York approved the concept,* IDA appeared by far the most logical contractual mechanism within which to house the group, and ARPA -- with its advanced research mission -- was the logical supervisory agency.

Unlike most of the post-Sputnik organizational responses, JASON (like ARPA itself) proved highly durable. It remained as a special division within IDA until 1972, after which it was transferred to the Stanford Research Institute for administrative reasons. In its new home, it continues to serve in a special consulting role very little different from that originally assigned.

In describing the functions of the JASON group, attention should again be turned to its membership. The individuals recruited were very high calibre young scientists, predominantly physicists, and their participation was largely made possible by the great technical challenges perceived in the Sputnik crisis and the widely shared feeling that defense problems were technological problems. While these perceptions were later to be modified considerably, the JASON's association with ARPA was to prove particularly appropriate to the capabilities and orientation of its membership because ARPA's main program after the space project transfers -- Project DEFENDER -- involved some of the most difficult technological and advanced physics challenges of any programs within the Department of Defense. Whether the issue concerned exotic weaponry such as charged particle or laser devices or exo-atmospheric and atmospheric phenomena produced by missile flight, there was a steady flow of problems for the group to consider. JASON members who joined the group at the beginning of the program tended to stay and ARPA (as the feeling of technological crisis declined) would have been hard-pressed to recruit replacements of equal calibre. In

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* As York put it, "To some extent JASON was invented or inspired by the patriotic motives of individuals who wanted to work on these very important problems which they thought of as being crucial for the national defense. At the same time, they wanted to make a lot of money at it. They were paid $200 a day.". (Discussion with Dr. H. York, April 4, 1975.) This no doubt contributed to the designation accorded JASON by the non-scientists in ARPA, namely, "the golden fleece."

1970, twenty-one of the 1960 JASON's were still participating (over half the 1970 group), despite the tremendous gulf between the DOD and the scientific community created by Vietnam.[85]

During both the Betts and later periods, JASON served several functions. Meeting in summer and autumn sessions, frequently in sub-panels rather than full membership, it was to provide collective studies and assessments on wide-ranging technical issues. JASON members were frequently employed to review programs, recommend areas for emphasis or deemphasis and to provide the conceptual groundwork for new project initiatives. Another function of the group, the most important in the opinion of many observers, was to provide a vehicle through which individual JASON members were educated in defense problems and technological issues, thereby enhancing their expertise and value as individual contributors to the resolution of defense-related issues.

The most significant JASON group contributions probably occurred in the early and mid-1960's under the successive ARPA directorships of Ruina, Sproull and Herzfeld. During this period JASON was to have all the characteristics of a tightly knit club (including rather posh arrangements for its beachside sessions at La Jolla, California or Woods Hole, Massachusetts, among other locations).[86] Moreover, JASON was regarded then as a highly successful club, with its technical studies said to have contributed to reinforcing judgments against NIKE-ZEUS deployment and (through answers to certain key questions on nuclear blast detection in the atmosphere) to the technical backup in support of the decision to sign the limited nuclear test ban treaty. According to Dr. Herzfeld, its DEFENDER-related work resulted in major contributions in wake theory, laser propagation and many other areas. He has said that he could always count on one to two "breakthroughs" of some importance each year from the JASON group.[87]

In the latter half of the 1960's, both JASON productivity and its esprit de corps appeared to decline significantly, along with the decline of ARPA's "Presidential issues" and the growth of the Vietnam conflict. JASON's involvement in Secretary McNamara's "electronic barrier" system, which was put forward as a solution to the North Vietnamese infiltration problem, became a major issue in 1966. The barrier was, of course, never implemented except in a highly piecemeal fashion; however, this issue became a source of division within JASON and a major difficulty for its individual members once their involvement became public knowledge and a focal point of campus controversy (most JASON members held university appointments).[88] In later years the strong individual personalities of JASON members and the difficulty of eliciting coherent group judgments and recommendations also came under increased attack.

Despite these problems, and some dissenting opinion on the group's overall contribution, the predominant assessment of this creation of the Betts period has been favorable over the years. JASON, York has said:[89]

> [W]as not at all as worthwhile as the people in it thought and still think. But, if you compare it with other things, it probably was [worthwhile]. They did work at a level of sophistication that was definitely a cut above -- speaking in terms of science -- what was going on in any other group that was directly connected with the defense program and had real access to what the problems are.

Following up this point, York stated that the quality of work was often very high and that while he might disagree "about how good JASON was, I did agree that it was worthwhile." Assessing the relative impact of JASON's scientific inputs on specific areas of Defense technology vis-a-vis other influences is virtually impossible, and the assessments from technically-qualified observers vary from York's rather subdued positive view to Herzfeld's "enormously useful."

Arms Control

ARPA's assignment in arms control research (also called ARA) is another example of DDR&E's use of ARPA during the Betts period as a convenient mechanisms to coordinate or monitor tasks where OSD-level supervision appeared preferable to more general DDR&E oversight of Service projects. In the case of arms control research (assigned in September 1960) the ARPA role was particularly circumscribed, since the Assistant Secretary of Defense for International Security Affairs (ISA) held primary responsibility. Basically ARPA was tapped as a funding source because ISA simply had no budget for even a modest research program. An early program statement on the assignment reads:[90]

> Arms control matters are of direct and continuing interest to the Department of Defense, in support of its national security responsibilities and in support of the development of U.S. arms control policy. Studies relating to arms control matters involving DOD functions and not directly connected with international agreements are the sole responsibility of DOD. Their impact must be studied, and projections must be made based on logical extensions of situations as they exist today. The Office of the Assistant Secretary of Defense (International Security Affairs) is charged with the responsibility for conducting policy studies in this area of interest and utilizes ODDR&E to conduct the required technical studies. ARPA acts as the administrative agent for efforts requiring contractual assistance.

Initial work under this project was largely restricted to RAND Corporation studies responsive to ISA requirements and contributive through ISA to the research program of the newly formed Arms Control and Disarmament Agency. The program later grew into the rather controversial CLOUD GAP program, which will be discussed in treating the ARPA programs of the Ruina period. While the assignment was somewhat logically related to the VELA program, insofar as nuclear test restrictions and arms limitations are complementary subject matter, the ARPA role in arms control was of clearly marginal importance. The subject did not involve a technical challenge of nationally recognized significance; hence ARPA was relegated to a cash disbursement role, funding RAND inputs to ISA's policy deliberations.

Energy Conversion

The energy conversion project, also known as Project LORRAINE, was one of the several smaller assignments developed for ARPA during the Betts period. However, unlike TORES, for which ARPA was employed as a convenient mechanism to resolve a DDR&E problem, LORRAINE was internally generated. It may, in fact, be viewed largely as a mildly successful attempt by ARPA and its IDA staff to salvage a minor part of its formerly dominant space mission and to use this as a basis for a new program initiative.

The direct antecedents for an ARPA project in energy conversion lay in the "Space Power" element buried in ARPA's large space program. "Space Power" expenditures had been about $2.3 million in FY 1959 and were $3.1 million in FY 1960. These small programs had been cut back from proposed larger efforts due to the budgetary constraints of the period.

In January 1960, in the midst of the space program exodus, Nathan Snyder of IDA prepared a program proposal for ARPA entitled "Research in Advanced Energy Conversion." Snyder argued that a number of the projects in the Space Power program were "of a basic nature and of general value to all Services" and should be retained by ARPA in the context of a broader energy conversion project not solely oriented toward space applications.[91] The rationale given was as follows:[92]

> An advanced energy conversion program involving fundamental aspects which are of importance to all military forces is nowhere to be found in the DOD. In the last year ARPA has served to stimulate and accelerate areas of research related to energy conversion far beyond that which had previously occurred. It would be tragic to scatter this effort by allowing it to be dissipated throughout several major systems developments. The continuation of this effort is more than justified; it appears to be vital and essential.

An ARPA program in energy conversion, defined to include "research in such fields as solid state physics, dynamic engine research, electrochemical conversion, solar energy and energy storage" was felt to have several advantages:[93]

> (1) There will thus be no oversight or undernourishment of basic research as is usually the case in many of the programs undertaken by the armed services in advanced energy conversion research because of the pressure to develop hardware or make budgetary changes which affect supporting research funding.
>
> (2) The national recognition of an advanced research activity in energy conversion focused within DOD which is broad and stands on its own will serve to accelerate the nation's effort in this area, avoiding confusion and assuring objectives that are technologically based. Under these conditions there will be versatility and little inertia for exploration of new important ideas.
>
> (3) Scientists and engineers in industry will find a single place to discuss new ideas and technological advances. Many scientists are anxious to perform research along the avenues of advanced energy conversion but have found insufficient support thus far from the Government.
>
> (4) University professors will find a single place to discuss new ideas and the possibilities of pursuing research in a technological field of great importance to the DOD. Universities have lagged seriously in the last few years in the development of new ideas and cogent research in energy conversion.

Precedent for an ARPA role in this field was found in the recent Materials assignment and explicit linkages were drawn between the two projects:[94]

> It should be noted that a close relationship is to be developed between the Advanced Energy Conversion program and the Materials Research program (Pontus) for universities now assigned to ARPA.... In the Materials Research program it is expected that some of the research by graduate students and professors will include the area of solid state physics and materials synthesis involved in the solid state energy conversion. Furthermore, basic research on the problem of corrosion involving the high temperature alkali metals and containment materials associated with them could be developed.

The "bottom line" of this energy conversion project proposal was that the bulk of FY 1960 "space power" projects which had been slated for transfer (mostly to the Air Force or Navy) should be retained by ARPA and used as the core of an initial $5 million per year program. It was anticipated that this might be expanded to an $8-10 million per year program by FY 1962. By February this proposal had been coordinated with the three Services and DDR&E and had received Service endorsement: "The general conclusion was that there was a great lack in research programs as compared to development programs, and that an ARPA program ... would be very important as a support to the needs of the military agencies."[95] The "selling" and coordination of this proposal was, incidentally, primarily handled by Snyder, an IDA employee.

The manner in which LORRAINE was generated illustrates several facets of ARPA during the transitional Betts period. The increasing prominence of basic research as an appropriate "multi-Service" role justification is one important feature. The justification for an energy conversion program is clearly similar to that for the Materials program, and appears in some respects to "ride the coattails" of that earlier assignment and its impressive endorsements. A second feature is the receptivity of the Services to an ARPA role in such fields. In the wake of Service success in regaining control of the major space development efforts, a residual ARPA role in more basic research endeavors must have appeared harmless, and perhaps even relieved the pressures of the scientific community for increased research support. Third, ARPA's continued reliance on IDA staff support, two years after the agency's creation, is evident. Thus, while program content is rapidly changing as General Betts becomes Director, the organization continues to rely on the staff arrangements of the Johnson period.

Reliability Studies (Project STRIVE)

Project STRIVE was undoubtedly the most trivial of the code-named assignments of the Betts period. It is included in this program review only to illustrate further the truly transitional character of this period and the rather awkward mixture of programs which ARPA held for a time.

STRIVE was merely a modest hang-over from the space period, and required ARPA to provide limited reliability evaluation reports on the four transferred satellite projects: MIDAS (early warning), SAMOS (reconnaissance), TRANSIT (navigation) and NOTUS (communications).[96] The reports were to provide information to the DDR&E to assist in his program review. This was clearly an interim function during the satellite program transition phase. Only $200,000 in FY 1961 funds were allocated to STRIVE. Although ARPA offered in FY 1962 "to consult with the Services on any future problems in this area," no new contracts were initiated. Nonetheless STRIVE enjoyed the same billing as DEFENDER as a formal ARPA assignment even though it was about 1/500th the effort. More than any of the formal post-space assignments, it indicates the cosmetic nature of the flow of code-named assignments. STRIVE was clearly not the equivalent of any of the transferred satellite programs, even though it kept ARPA nominally on the fringe of these programs for another year.

The TORES Assignment

TORES, the "code name" for a program of toxicological investigations relating to the hazards of propellants and other chemical materials in military use, was scheduled for assignment to ARPA in April by Dr. York, via memorandum to the Service Secretaries. The program was formally assigned in November 1960, as an enclosure to the ARPA Directive, with the name TORES derived from toxicological research.

TORES was one of the many minor assignments made during the Betts directorship which in later years would likely have been simply added to some existing office (perhaps, say, the Materials office) without any great fanfare. The tradition that each ARPA assignment should have a code name and be formally appended to the ARPA charter died within a year of Betts' departure, but in 1960 TORES received the same formal billing as DEFENDER or VELA. The effort, however, received only $800,000 in funding in FY 1962 and was gone by FY 1963.

TORES is of interest to the ARPA history, therefore, not because of any inherent importance, but because it illustrates some of the contemporary thinking in DDR&E as to how to use ARPA following its departure from outer space missions. As illustrated by TORES this thinking seems to be much in line with General Betts' view of ARPA primarily as a convenient mechanism for DDR&E to handle research problems of a multi-Service character. There is nothing in the TORES assignment to indicate any strong DDR&E feeling that ARPA should be limited to problems of national important, revolutionary implications or crucial "anti-Sputnik" level significance.

The toxicology problem became a candidate for an ARPA program in a meeting held between DDR&E and ARPA staff members on December 7, 1959.[97] The issue in question was simply that a joint-Service funded project on health hazards and military chemicals, conducted at the Army Chemical Center, Edgewood, Maryland which was encountering problems because of fiscal difficulties. The project had been in existence since 1949, with each Service providing about $75,000 per year, but the demands of the missile era and the accelerating use of toxic propellants generated a need to upgrade the program. At the December meeting it was proposed to add $500,000 through the DOD budget to expand the Army Chemical Center program and ARPA agreed to monitor the program "if directed to do so by the DDR&E."

In the April 1960 announcement that ARPA would receive this assignment, the DDR&E defined ARPA's role rather sharply.[98] The Army Chemical Center, for example, was designated as "the primary agency to perform research and investigations," and "... to further aid ARPA in assigning relative priorities for toxicological investigations in consonance with the capabilities of the Chemical Warfare Laboratories, the advice and assistance of a representative from the NAS-NRC Advisory Center on Toxicology, and suitable consultants to DDR&E will be required periodically." ARPA was further restricted to monitoring the toxicology studies per se. "Determination of the environmental and occupational health hazards" based on these studies was left to the Military Departments.

It is thus clear that ARPA was brought into this field in order to help get around a funding problem and to provide additional monitoring of a quite circumscribed joint Service endeavor. ARPA clearly did not have the charter to take major new initiatives or institute large organizational changes in military toxicology research. It was expected to play a cooridnative role, but appears to have been selected largely as a convenience.

Although nothing came of it, there also was considerable discussion of giving ARPA an assignment in biological and chemical warfare research (BW/CW). York promoted the idea of attempting to develop non-lethal weapons:[99]

> I thought that the non-lethal elements of that [BW/CW] would be useful. It was only a few years later that I decided ... that I think of that as the main mistake that I made in the Pentagon. Actually, nothing came of that mistake ... I remember trying to persuade McElroy and either he had a hard night or something, but he couldn't keep awake.... McElroy just couldn't keep awake and Gates regarded it as abominable. Nobody ever liked BW/CW in the Pentagon.

Thus ARPA was spared entry into another highly controversial area.

BETTS' DEPARTURE

General Betts' term as ARPA Director, begun with modest expectations concerning ARPA's role and mission, ended on a low-key note. In December 1960, he accepted an offer to become head of the AEC Division of Military Application. This was a prestigious post in a military research and development career, and Betts (with Dr. York's full concurrence) felt that he should not refuse it. Betts left ARPA for the AEC in January 1961, his departure coinciding with the end of the Eisenhower Administration.

The Betts directorship thus ended after one year for the most straightforward of reasons. In retrospect, he is favorably remembered by his staff as a taciturn, dedicated, extremely hard-working man, who lacked the flash of his predecessor and a number of his successors, but who provided stability to a badly-shaken organization at a critical point in its history.

Under Betts, ARPA survived its transition from the space programs and a foundation was laid for a more ambitious and aggressive interpretation of ARPA's role in the early sixties.

As a matter of personal judgment, Betts today is a strong supporter of the ARPA concept, in these terms:[100]

> I always felt that ARPA's role properly was to those jobs that were of multi-Service interest, to at least two Services, and that therefore could be better coordinated by ARPA doing it than by giving it to one Service, then watch them slowly freeze the other one out of existence. And frankly I still feel today that that's ARPA's proper role.

Under Betts ARPA had survived, but not really prospered. Three months before the General's departure, J. P. Ruina of ODDR&E (later to be tapped as Betts' successor) told the ARPA Program Council, with his own special brand of directness:[101] "ARPA is not strong now because it is not supported by Dr. York as it had been by McElroy when Mr. Johnson was here." ARPA apparently still faced an uphill climb. Ruina also chastized the Agency for not taking stronger stands against the military and especially for being too tolerant of the Services' desires and programs when they interfered with DEFENDER. It was left to Ruina to re-fashion an aggressive ARPA.

CHAPTER IV: FOOTNOTES

1. Discussion with W. H. Godel, June 18, 1975.

2. DATA Magazine, "A Case of Conscience?," editorial by Martin Caidin, December 1959, 25.

3. Memorandum for the Secretary of Defense from R. W. Johnson "Nominations for Director, ARPA," October 20, 1959.

4. Ibid.

5. Discussion with L. P. Gise, April 7, 1975.

6. Time Magazine, November 15, 1959.

7. See letter to H. Roback (Staff Administrator, Military Operations Subcommittee, Committee on Government Operations, House of Representatives) from Major General N. Moor, Director of Personnel Policy, February 16, 1960.

8. For an interesting pro-Critchfield review of this situation, see George E. Sokolsky, "The Stupidity of It," Washington Post November 20, 1960.

9. Discussion with L. P, Gise, April 7, 1975.

10. Interview with Dr. H. F. York, April 4, 1975.

11. Interview with Lt. Gen. Austin Betts, U.S.A. (ret.), April 7, 1975.

12. Discussion with W. H. Godel, June 18, 1975.

13. Discussion with Col. D. Lay, June 17, 1975.

14. Undated paper entitled "Concept," apparently circulated by Maj. Gen. D. R. Ostrander, Acting ARPA Director. Staff responses to subject paper are dated November 19, 1959.

15. Department of Defense Directive No. 5105.15. (March 17, 1959) "Subject: Department of Defense Advanced Research Projects Agency."

16. Department of Defense Directive No. 5129.33 (December 30, 1959) "Subject: Department of Defense Advanced Research Projects Agency" (reprinted with changes through September 8, 1961 incorporated). Changes apply to new assignments attached to directive.

17. House Subcommittee on Appropriations, DOD Appropriations for 1961, Hearings, 86th Cong., 2nd Sess., March 11, 1960, 160-161.

18. Discussion with Dr. H. F. York, April 4, 1975.

19. Ibid.

20. Discussion with Lt. Gen. A. W. Betts, April 7, 1975.

21. Ibid.

22. Ibid.

23. Ibid.

24. Ibid.

25. During Betts' tenure and the early Ruina period all assignments to ARPA were included as attachments to the December 1959 Directive. See ref. 16 above.

26. Discussion with Lt. Gen. A. W. Betts, April 7, 1975.

27. Ibid.

28. Memorandum for ARPA and ARPD/IDA Personnel from A. W. Betts, "ARPA Organization" May 13, 1960.

29. Discussion with L. P. Gise, April 7, 1975.

30. Remarks by R. W. Johnson, Director, ARPA at a Meeting of the Board of Trustees, Institute for Defense Analysis, October 24, 1958. Undated transcript.

31. Discussion with Lt. Gen. A. W. Betts, April 7, 1975.

32. Illustrated by a memorandum from R. W. Johnson, to the Assistant Secretary of the Air Force (R&D) "Participation of ARPA-IDA Personnel in Development Inspections" March 3, 1959. It concerns the presence of a Boeing "leave of absence" IDA employee at an inspection at the Martin Company.

33. Discussion with L. P. Gise April 7, 1975.

34. Memorandum for the Director, Defense Research and Engineering from Lt. Gen. A. W. Betts, "DDR&E/IDA/ARPA Relationships" April 21, 1960.

35. Thomas C. Thayer, "The Institute for Defense Analysis: An Effective and Proper Device for Defense Management?" May 1, 1959 (internal ARPA review) 14.

36. Discussion with L. P. Gise, April 7, 1975.

37. Ibid.

38. Memorandum for the Secretary of Defense/Deputy Secretary of Defense from R. W. Johnson, "ARPA Organization" December 5, 1958.

39. ARPA Bulletin No. 9, October 22, 1958.

40. Memorandum for the Staff, "ARPA Bulletin No. 9, Amended Establishment of ARPA Program Council," February 16, 1959.

41. Discussion with L. P. Gise, April 7, 1975.

42. Memorandum for the Secretary of Defense/Deputy Secretary of Defense, from R. W. Johnson, "ARPA Organization" January 20, 1958.

43. Discussion with Dr. Charles Townes, July 10, 1975.

44. Memorandum for the Staff, from Lt. Gen. A. W. Betts, "ARPA-ARPD/IDA Relationship," March 9, 1960.

45. Memorandum of May 13, 1960, op. cit. (reference 28).

46. Ibid.

47. Exchange of Memoranda between Deputy Secretary of Defense Douglas and H. F. York, dated July 9, 1960 and July 18, 1960.

48. Discussion with Dr. A. Rubenstein, February 21, 1975.

49. Memorandum of April 21, 1960, op. cit. (reference 34).

50. Discussion with Dr. R. Holbrook, July 10, 1975.

51. Memorandum for the Director of Defense Research and Engineering from S. J. Lukasik, "Annual Review of IDA (exclusive of WSEG Part)" (DRAFT) November 26, 1969.

52. Discussion with Lt. Gen. A. W. Betts, April 7, 1975.

53. Discussion with Col. D. Lay, June 17, 1975.

54. Discussion with Lt. Gen. A. W. Betts, April 7, 1975.

55. Program scope described in "Information Sheet for Prospective Bidders on ARPA's Guideline Identification Program for Anti-Missile Research (GLIPAR), Phase I" January 28, 1959. (Unsigned ARPA paper.)

56. "ARPA Plan," ARPA budget projection table submitted to ODDR&E and dated July 15, 1959.

57. Discussion with Dr. H. F. York, April 4, 1975.

58. Discussion with Dr. R. Holbrook, July 10, 1975.

59. Discussion with Dr. D. Dustin and Dr. J. Freedman, July 2, 1975.

60. The report, entitled "Lincoln Laboratory Evaluation of the ARPA Press Program" was cited in Ibid.

61. Discussion with Dr. R. Holbrook, July 10, 1975 and Dr. B. Alexander, July 8, 1975, and Ibid.

62. Discussion with Dr. J. P. Ruina, May 9, 1975.

63. Discussion with Dr. D. Dustin, July 2, 1975.

64. Discussion with Dr. H. F. York, April 4, 1975.

65. House Subcommittee on Appropriations, DOD Appropriations for 1964, Hearings, May 10, 1963, 211.

66. U. S. Department of State, Documents on Disarmament, 1960, (Washington, D. C., 1969). Contains numerous documents generated by Geneva negotiations.

67. Harold K. Jacobson and Eric Stein, Diplomats, Scientists and Politicians (Ann Arbor: University of Michigan Press, 1966) 389-91.

68. Joint Committee on Atomic Energy, Developments in Technical Capabilities for Detecting and Identifying Nuclear Weapons Tests, Hearings, 88th Cong., 2nd. Sess., March 5-12, 1963, 401.

69. Ibid., 400.

70. Ibid., 394 and 401.

71. Jacobson and Stein, op. cit., 382.

72. Discussion with Dr. H. F. York, April 4, 1975.

73. Jacobson and Stein, op. cit., 197.

74. Ibid., 198.

75. Discussion with W. H. Godel, June 18, 1975.

76. Discussion with Dr. H. F. York, April 4, 1975.

77. ARPA Semi-Annual Report, September 1960, (Confidential) Unclassified section cited, 25.

78. Discussion with Lt. Gen. A. W. Betts, April 7, 1975.

79. Ibid.

80. Attachment to Reference 16.

81. ARPA Semi-Annual Report, September 1960, (Confidential) Unclassified section cited, 22-24.

82. House Subcommittee on Appropriations, DOD Appropriations for 1961, op. cit., 165.

83. Attachment to Reference 16.

84. Discussion with Dr. H. F. York, April 4, 1975.

85. Memorandum for Record from S. J. Lukasik, "JASON Management," January 27, 1970.

86. For a review of JASON in the late 1960's and early 1970's, see "JASON Division: Defense Consultants Who Are Also Professors Attacked," Science, February 2, 1974, 459ff.

87. Discussion with Dr. C. M. Herzfeld, September 17, 1975.

88. See Ref. 86 above and "The Secret War Over Bombing: Society of Physicists Torn by Moral Questions," The Philadelphia Inquirer, February 4, 1973.

89. Discussion with Dr. H. F. York, April 4, 1975.

90. ARPA, Semi-Annual Summary of ARPA Activities as of October 31, 1961, (Originally Confidential, Group 4; Declassified per G.D.S.). Unclassified section cited, 35.

91. Nathan W. Snyder, "Research in Advanced Energy Conversion" January 4, 1960 (IDA IM-155).

92. Ibid.

93. Ibid.

94. Ibid.

95. Nathan W. Snyder, "Research in Advanced Energy Conversion for Electric Power," February 11, 1960 (IDA TE-252).

96. ARPA Semi-Annual Report, September 1960, (Confidential). Unclassified section cited, 32.

97. Memorandum for File, "Toxicological Investigation Services" (ARPA/unsigned) December 7, 1959.

98. Memorandum for the Secretary of the Army/Navy/Air Force, from H. F. York, "Consolidation of Toxicological Investigations," April 14, 1960.

99. Discussion with Dr. H. F. York, April 4, 1975.

100. Discussion with Lt. Gen. A. W. Betts, April 7, 1975.

101. Memorandum for the Record from D. K. Hess, "Dr. Jack P. Ruina's Philosophy on DEFENDER Project," November 4, 1960.

ARPA AS A TECHNOLOGICAL ELITE

THE RUINA DIRECTORSHIP: 1961-1963

The years 1961-67 represent ARPA's own "golden age" in the sense that the Agency is relatively free of hostile political attack and enjoys a definite measure of esteem for its scientific and technological achievements. Fortuitously perhaps, the man selected to kick off this era was admirably suited by both background and inclination to redeem the promise of the "basic research and special projects" oriented ARPA sketched out in the ARPA staff paper prepared at Roy Johnson's departure. Gen. Betts had cleared away some of the underbrush and held the Agency together. Dr. J. P. Ruina -- looked upon by ARPA staff as a member of the scientific establishment -- was to fashion it in the image of an elite group concerned with "quality science and technology" in the realms of basic and applied research and exploratory development, as those terms are customarily used in DOD.

The Setting - 1961

The first few months of 1961 occasioned perhaps the most extensive changes in ARPA's operating environment in its history. This is exemplified by the many personnel changes which followed the shift from a Republican to a Democratic administration. Some of these changes were a product of the Kennedy election; some were coincidental. The total effect, however, was a considerable break in continuity.

The highest level change in the Defense Department was, of course, Robert S. McNamara's appointment to succeed Gates as Secretary of Defense. McNamara assumed office with the Kennedy mandate to seek out additional defense "options," including improvement of the nation's nuclear second-strike capability, increased conventional war capabilities, and improved management throughout the Department. The "massive retaliation" philosophy was abandoned in favor of General Maxwell Taylor's "flexible response" approach. To implement these changes, McNamara successfully advocated a considerably expanded Defense budget, while at the same time supporting vigorous new approaches to cost control.

Shortly after the new Secretary arrived the Director of Defense Research and Engineering was also changed. Dr. Harold Brown replaced York, who had been plagued by health problems for much of his tenure as DDR&E and decided to resign. Dr. Brown, like York, a brilliant scientist and former head of the Livermore Radiation Laboratory, represented another significant change since he was not intimately connected with the in-fighting over the space programs and thus shed part of the legacy of conflict unavoidably associated with Dr. York. Brown also had had no prior connection with ARPA.

Significant personnel changes took place within ARPA and that also helped to moderate potential tension between ARPA and DDR&E. Shortly before the new Administration came into office, General Betts resigned. He was replaced by Dr. Jack P. Ruina, the first scientist-director of ARPA, who moved from his position as Assistant Director for Air Defense in DDR&E. Ruina had been a university professor and a Deputy Assistant Secretary of the Air Force and he held strong views about both research and the Defense Department. On good terms with PSAC members, Ruina said that he had much closer rapport with PSAC thinking than with people in DOD.[1] He and York had interacted constantly with PSAC on questions dealing with BMEWS, the Sage system, BMD deployment, etc. York also relied on Ruina for advice on DEFENDER problems that were raised to the DDR&E level, to the point that Ruina said "I felt almost that I was running it."[2] While a York appointee, both to his DDR&E and ARPA positions, Ruina meshed smoothly with Brown, due in part to their common professional backgrounds. At the Deputy Director level, L. P. Gise, the Agency's senior administrative official, departed in March 1961, and was replaced by Dr. George Rathjens, a scientist not associated with space issues who had been recruited to serve as Chief Scientist late in the Betts period.* Replacement of IDA staff -- another link with the "space era" -- was far advanced by early 1961 as a result of the reorganization initiated by Betts. ARPA military staff had also, by this time, largely turned over due to normal rotation. The only senior ARPA professional remaining from the early days, William H. Godel, had turned his interests increasingly from matters of space to the emerging issues of limited war and guerrilla conflict.

1961 began, therefore, with the need to adjust to the goals and priorities of a new Administration and a new DOD management team. The fresh personalities in DDR&E and ARPA appeared to draw these two organizations together and to enable both to shift markedly from the concerns which dominated the 1958-1960 period.

Externally, events were in train that would also affect ARPA's role and stature. Several served to buttress fears of the Soviet threat and to drive liberal and conservative politicians together in support of a "strong" defense policy. While the "missile gap" arguments of the campaign quickly faded when Kennedy came into office, fears of U.S. inferiority were intensified by two events in April: (1) the USSR's successful man-in-space flight -- another Soviet "first" -- and (2) our inability to control developments in Cuba culminating in the Bay of Pigs fiasco. Political-military frustrations continued in Europe, peaking with the erection of the Berlin Wall in August. The fragile nuclear test moritorium continued to be marked with great suspicion, which finally appeared to be confirmed by the sudden resumption of Soviet nuclear tests in November. The U.S. role vis-a-vis the developing world was also in turmoil. The conflicts in Laos and Vietnam

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* Rathjens combined both the Chief Scientist and Deputy Director positions after Gise's departure. After Rathjens left ARPA the former position was allowed to lapse, given the technical qualifications of successive Directors and Deputies and difficulties in recruiting outstanding scientists to fill the position. There were only three Chief Scientists after York.

were worsening. In May Vice President Johnson visited South Vietnam to show support for Diem and Thailand to woo Marshal Sarit as an ally. Africa was in chaos, with the assassination of Patrice Lumumba in February followed by a year of severe conflict in the Congo, and by Dag Hammerskjold's accidental death in September while on a cease-fire mission. The threat of export of the Cuban revolution throughout Latin America appeared very real. All of these events combined to provide the setting for an expansive defense program. Eisenhower's departing FY 1962 DOD budget request of $41.8 billion was raised twelve per cent to $46.7 billion, the highest Defense budget since the Korean War year of 1951.

Organization and Management

Ruina's appointment as Director of ARPA was apparently greeted with mixed feelings by some members of the ARPA staff, both because he was a member of the DDR&E staff, with which ARPA's relations were frequently strained (in fact, for a time Ruina maintained certain DDR&E responsibilities after coming to ARPA), and because he was felt to have strong negative feelings concerning both the DEFENDER program and certain basic tenets of ARPA's "organizational philosophy."

Considerable insight into the questions which must have arisen upon Dr. Ruina's appointment is provided by a memorandum for the record prepared by D. K. Hess on a meeting between Ruina and the ARPA Program Council on November 3, 1960.[3] This memorandum was written just a few weeks before Ruina received the ARPA appointment, and before that appointment was known to be pending. Speaking from his Air Defense position in DDR&E, Dr. Ruina was described as critical of the ARPA Program Council as a bottleneck, hostile to ARPA's use of military officers on the staff because they were not sufficiently oriented to research, intolerant of ARPA's cautious relations with Service contracting agents, and skeptical of the Agency's extensive use of advisory committees. In addition, Ruina was reported to be quite outspoken concerning perceived management problems in the DEFENDER program, generally arguing for a very flexible approach with, in Hess' words, "a minimum of red tape in procedures." Since Ruina was "least interested in [the] details of management," it followed that he would wish to reduce such details to the minimum.

Dr. Ruina's subsequent arrival did not, however, result in any revolutionary change in ARPA's organizational approach. It continued, as it has to the present, to maintain a substantial military staff. Similarly, it continued to rely on the established Service agent system for contracting and continued to solicit the advice of advisory committees. Dr. Ruina also gradually came to appreciate the necessity for a certain amount of bureaucratic red tape in DEFENDER and other programs, though he maintained a distinct distaste for many bureaucratic requirements.[4] There were, however, significant and lasting changes in both management style and program content during the Ruina period.

To begin with the question of management style, the clearest impact of the Ruina era was to bring about a distinct decentralization of research management within ARPA and increased reliance on strong office directors to develop their separate technical programs. Betts had started to introduce this system, but Ruina actually put it in place, creating what a later ARPA Director was to call a tradition of independent office "baronies." As it worked out, the Chief Scientist and the Technical Operations Division on the technical side and the Program Council on the management side were eliminated as layers between the office Director and the Director of ARPA. Ruina wanted, and got, a "one-on-one" style of operation. He encouraged forceful office leadership, e.g., Herzfeld (a future Director of ARPA) in DEFENDER; J. C. R. Licklider, who shaped the Command and Control and Behavioral Sciences programs; and Godel, the de facto leader of the new AGILE assignment. There was considerable leadership turnover in the nuclear test detection office, but it received a great deal of attention from the new Director and Deputy Director, both of whom had strong personal interests in that program. Toward the end of the Ruina period, Dr. Robert Frosch was appointed to head VELA and became a strong and somewhat controversial leader of that office in the Sproull period. Men like Ruina and his immediate successor, R. L. Sproull, thought of themselves as transients, not career men. They tended to feel that it was healthy for ARPA to bring in top flight office directors as well for two year assignments, on the theory that the best men would rarely desire government careers, ARPA would benefit from exposure to fresh views, and the Agency's flexibility would be enhanced. This theory was similar to the original rationale for the IDA staff. The main difference was that the encumbents would be civil service appointees. The success of such a system depends on the quality of the Director, the nature of the Agency's program assignments, and the relative status of the DOD.

The Program Council mechanism faded in importance and eventually disappeared. As one of its primary advocates admitted, it had "degenerated into a game as to who could be meanest in terms of project review."[5] The hostility of the technical office directors mounted. These individuals tended to feel that the Council had become competitive rather than mutually supportive of Agency objectives. As a consequence, they would appeal individually to the Director on matters being addressed by the Council and attempt to undercut its authority. Since Ruina felt that "nobody there had the wisdom as to what made technical sense"[6] and that it was a bureaucratic obstacle which slowed progress, it is hardly surprising that the office directors prevailed and Ruina ultimately disbanded the Council.

Describing the flavor of the ARPA independent office director system under Ruina, one of his successors stated:[7]

> One of the things that Jack .... communicated, and we had gotten this [description] from others ... was that these [the office directors] were very strong people that wanted to be connected in with

> the work in other than a bureaucratic way. That is to say, they wanted to know the work that was being done, they represented it, they wanted to talk directly with the guy doing it, they were interested in talking technical things when you went to their offices.

In essence, the office structure under Ruina was characterized by strong personalities and by a very marked substantive, rather than administrative orientation. As will be illustrated later, this flavor tended to continue in ARPA and is one of those characteristics often cited to distinguish ARPA from, say, the National Science Foundation (NSF). Though the seeds of this were present in the space period, it is clear that the new and embattled ARPA of 1958-1960 could not speak to the scientific community with quite the confidence it could muster thereafter. Relieved of much of the non-technical burden that originally had been foisted on the new Agency -- roles and missions disputes, coordination of space vehicle launch schedules, etc. -- ARPA concentrated on its programs. The public and internal DOD debates about abolition of ARPA ceased completely. The closest ARPA came to an organizational realignment is an agreement by York and Ruina, approved by McNamara, that Ruina have a dual appointment as Director of ARPA and Director for Air Defense in DDR&E. At the last minute, York withdrew the idea, deciding that the two jobs would be too demanding and Ruina subsequently decided that York's evaluation was correct.*

There was little "Why ARPA?" questioning during Ruina's period. Before Congress, Ruina merely stated that ARPA functioned as an integral part of the Office of Defense Research and Engineering, working as a line agency on projects assigned by the Secretary or by the DDR&E that normally "are either of interest to more than one of the military departments or lie outside the specific missions or interest of all of them."[8] He received no challenge, but if there had been any, the answer undoubtedly would have been 'take it up with the DDR&E, that's who tells us what to do.' Internally, feuding with the Services was minimal. There was no need to appeal to ARPA's Charter to sustain its legitimacy. In fact, Ruina does not recall ever reading or worrying about what the language of the charters was.[9] Thus the image of ARPA as a technocracy crystallizes in the Ruina period.

ARPA Priorities

York gave Ruina no particular instructions about handling ARPA. He had no specific program suggestions to make. Compared to such burdensome issues as SKYBOLT, MINUTEMAN and NIKE-ZEUS deployment, the ARPA programs were "small stuff." In essence, Ruina's mandate was "run it." This attitude reaffirmed an ARPA characteristic that started with Roy Johnson and continued at least into the late 1960's: while arguments over ARPA

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* It remained for John Foster to appoint an ARPA Director, Dr. Eberhardt Rechtin, as a Deputy DDR&E in 1970. This dual appointment failed in practice and Rechtin's deputy became de facto chief of ARPA.

assignments might be bitter and the decisions carefully controlled, once assigned projects the Agency has had a remarkably free hand to carry them out however it saw fit.

Ruina's basic image of his inheritance was that it was erratic. Beset by what he considered to be "a very volatile history," Ruina felt that ARPA had never "had a steady state to which one could point to."[10] He had definite ideas about defining such a state. Senior ARPA staff recall an initial period of apparent drift when Ruina took over and some difficulty in communication. In part this was because he was intent on transforming ARPA into a decidedly different organization than it had been and there was a certain inertia to be overcome. He has said that in many respects he always had felt closer to PSAC, in terms of spirit and values, than to DOD, and this was reflected in his conception of what ARPA should become: "The place I'd like ARPA to be was to be an extremely high power."[11] To achieve "high power" status, scientifically, was to mean according a far greater weight to "good science" than to immediate defense relevance:[12]

> [I]n the long pull, the immediate relevance of what they are going is going to be less important than the fact that they have done some very good things, and they have a long-term implications... projects should be supported on the basis of a product with two qualities -- its scientific and technical merit and its relevance ... I weighed that scientific merit more.... Things which make a mark in scientific history -- and that was sort of an underlying theme. I always felt that if you can get some very good people doing interesting things, that would be more important than the fact it was relevant.

ARPA's forthcoming deep involvement in basic and applied research was no accident. It was a matter of conscious choice, with serious implications for the future. The DDR&E's (York and Brown) approved and so did the Congress, as Ruina succeeded in rebuilding ARPA's budget to the $250 million level. Relations with the White House science apparatus were never better.

The move away from relevance was relatively easy because of the still strong feeling that just about any R&D effort would be beneficial for DOD. Furthermore ARPA was able to wrap a great deal of basic and applied research in the mantles of ballistic missile defense, nuclear test detection, propellant chemistry for missiles, and materials research for "advanced systems." This trend did not go without challenge within the Agency. Some of the management staff warned that the scientists were hiding behind the "military urgency" label to do things they wanted to do, but couldn't justify elsewhere. Godel, for instance, paraphrased what ARPA was doing as making it "as legal [for university scientists] to steal from the Pentagon as anywhere else," simply by logically contouring the justification to do it.[13] Likewise D. K. Hess, a highly regarded former Director of Program Management, felt that ARPA came close to being a U. S. Science Agency in the early 1960's because it claimed as "military" a host of things that were unable to obtain funding at NSF or other sources.[14] Nonetheless it was done because the scientific and technological leadership decided that it "ought" to be done.

In programmatic terms, Ruina established ballistic missile defense and nuclear test detection as the Agency's top priority activities. He came to the former area with a strong background from previous work in the Air Force and DDR&E and to the latter with an attraction grounded in what he calls his "political liberalism." His successor, Dr. Robert L. Sproull, was also drawn to ARPA in large measure because of the challenge posed by the VELA problem. It was also clear to Ruina that BMD and test detection were issues of national significance -- truly Presidential issues -- and that they should warrant the best that the Agency had to offer, including the lion's share of the Director's time. Both concerned subjects which were matters of great controversy during the Kennedy Administration.

In ballistic missile defense, there was a vigorous fight waged for deployment of the NIKE/ZEUS by segments of the military and industry in 1961; it was decided in 1962 to kill ZEUS deployment; and in 1963 NIKE-X emerged as the preferred potentially deployable system. ARPA's DEFENDER program was deeply involved in the technology that distinguished NIKE-X from ZEUS; hence ARPA was in a position to supply important technical inputs to the continuing policy debate. Regarding nuclear test detection, Soviet violation of the nuclear test moritorium in 1961 was followed by a resumption of U. S. testing; 1962 was a year of intensified negotiations on a test ban; and in July 1963 agreement was reached on a limited test ban. Again, the ARPA program provided many of the technical inputs to policy deliberations. Ruina has described the times as follows:[15]

> [One of the] programs ... I got involved in in a very personal way -- that I was deeply interested in -- was Nuclear Test Detection.... It was of national importance, and I am sure that issues that are of national importance do excite you more. Congress was worried about it. We were signing treaties, or not signing treaties, on the basis of presumably what ARPA was doing. [Similarly] the ABM. [We] were deploying or not deploying. So ABM and Nuclear Test Detection were issues that the Secretary of Defense and PSAC and McGeorge Bundy were worried about. So, obviously, you know.... That's the important stuff. So when you got back to the Agency you were worried about that.

While DEFENDER and VELA held center stage, due to their intimate relationship to major national issues, a large second block of ARPA funding occupied relatively little Director's time but grew steadily with an apparent solid base of support. This was, again, the development of major support for basic research. Included in this block of support was the work in materials sciences, information processing and behavioral sciences, as well as support for basic seismology within the VELA program, work in nuclear and atmospheric physics in DEFENDER, and basic research support in other offices such as solid propellants and energy conversion. The impetus behind this Defense interest in basic research, of course, traces to Sputnik and the feeling that the U.S. was in danger of falling behind the Soviet Union in a number of important scientific fields. The rapid growth of support beginning in 1961, however, also reflects the substantial expansion of the Defense budget following the change in Administrations. The $6.4 billion increase of the first Kennedy Defense appropriation over Eisenhower's last Defense appropriation bought considerable flexibility for the funding of low-cost basic research efforts. During Dr. Ruina's tenure, these programs engendered relatively little controversy and, heavily weighted with broad institutional support, give the appearance of almost having run themselves. Although creating a climate within which a number of these programs could flourish, Ruina's personal involvement with them was peripheral:[16]

> The others, I don't even remember what the key issues were. I couldn't even remember [their] budgets.... I didn't know much about them. Propellant Chemistry I am not sure I did understand to the very end. I knew what they were doing, but I didn't have a real feel for how important it was and what the likelihood was, that a propellant, the type they were looking for, was really that important.

The IDL program was a partial exception to this generalization because, as Ruina said, "my life was with the university and I was quite sure I was going to go back to it [and] this major involvement of DOD in what looked like a very enlightened way in university affairs was interesting ... and so I was involved."[17] Ruina found Command and Control and the Behavioral Sciences to be "challenging thoughts," but was neither positive or negative about receiving these tasks. The rest of them, particularly the flurry of Betts period assignments, "I really didn't want them."[18]

The third major program to emerge during the Ruina period was Godel's AGILE program, ARPA's venture into the world of limited warfare and counterinsurgency. At first, and through much of this period, heavily colored by quick-fix equipment adaptation programs, this effort was also close to an issue of national debate, but a debate with quite vague and misty boundaries. In the 1961-1963 period, it must be remembered, it was not at all clear that Vietnam would come to occupy its place of dominance for the next decade. As of the end of 1962 there were still only about 10,000 U. S. advisors in Vietnam, the Diem overthrow was about a year away and the Tonkin Gulf incident almost two years distant. The threats of export of Cuban communism to Latin America or of a wave of revolutionary communism throughout Africa appeared equally serious to many. The AGILE program was created to provide a research contribution in this highly uncertain environment. It is perhaps telling that both Dr. Ruina and Dr. Sproull, his successor as ARPA Director, used the same adjective to describe their personal view of AGILE -- "uncomfortable."[18] Indeed, said Ruina, "AGILE was one I tormented over. [It] never appealed to me."[19]

Dr. Ruina's dominant concern with the major "Presidential issues" of the day -- issues which occasioned lively debate in the scientific community -- is altogether understandable. It is of some interest to note here, however, that of the ARPA programs which became dominant in the late 1960's, almost all were beginning to develop during the Ruina period, but were not among his priority interests. These programs included AGILE, information processing technology, and behavioral sciences research, as well as what at the time were marginal parts of DEFENDER (e.g., lasers, OTH radar, optics), materials projects other than institutional funding, and aspects of nuclear test detection which then were of distinctly secondary interest, e.g., evasion research and diagnostics. By the late sixties ARPA would have transferred the core of the DEFENDER programs which occupied Ruina's attention, would be planning to transfer the materials laboratory effort, would have completed a major success with nuclear test detection satellites, and would have carried underground test detection research to the point where transfer or termination received considerable discussion (though no treaty was achieved to put ARPA's research to the test). While Ruina's high-priority items were therefore reaching some form of culmination by the late 1960's, the seeds of much of ARPA's efforts at the end of the decade were planted in those project areas below the Director's level of attention. This gradual internal evolution of projects -- arising without splashy assignments or grand debate -- is a central feature in the changing character of ARPA. Following the Pen Aids and AGILE assignments in 1961, ARPA never again received a "Presidential issue" program.

Program Management and the Use of Service Agents

Midway through Dr. Ruina's directorship, ARPA sponsored a contractor study of its management of the DEFENDER program which touched on many aspects of program management and the use of Service agents.[20] The study is of interest here, not because it arrived at any startling conclusions and recommendations, but because it provides a summary documentation of many of the then-current characteristics of ARPA management, both within and outside of DEFENDER. These characteristics were to change remarkably little from the ARPA which emerged from the space-transfers to the ARPA of the 1970's, so that the following discussion concerning Dr. Ruina's ARPA applies to a great extent to the years thereafter.

The study confirmed a central feature of Ruina's ARPA, namely the preeminent influence of individual technical managers within each of the program officers:[21]

> Perhaps the most outstanding feature of management within ARPA, and certainly the one which most impressed us during this study, is the extensive responsibility assigned to a relatively small group of scientific and engineering men. On DEFENDER, for example, a technical manager was normally found to be responsible for a broad range of functions, including:
>
> 1) the over-all planning, direction and supervision of research in his area or areas of responsibility;
>
> 2) coordination of his efforts with those of other technical managers working on DEFENDER;
>
> 3) evaluation of unsolicited proposals and the selection of both agents and contractors to undertake new work;
>
> 4) monitoring of agent and contractor progress on existing efforts, and the evaluation of results upon completion of their tasks; and
>
> 5) preparation and justification of the annual budget for his projects or areas of responsibility.
>
> While the workload generated in the performance of these functions varied from subproject to subproject among those that we studied, an 'average' workload profile would show that a technical manager was:
>
> a) heavily involved in one area, such as molecular physics, or in a single large research project, such as ARPAT, but at the same time was also concerned with a number of smaller projects spreading across several technical areas;

b) responsible for a total budget of approximately $5 M/yr., allocated among 5 to 15 ARPA Orders ranging in dollar size from $50 K/yr. to $1,000 K/yr.;

c) dealing with agents in each of the three military services, and occasionally with technical groups in non-defense government agencies as well as contracting personnel in OSD; and

d) directing and monitoring an average of 10 to 15 prime contractors, possibly including one or two universities, that were geographically dispersed throughout the country from coast to coast.

> To do this work, the technical manager might have support from his counterparts on DEFENDER, who have similar functions but often in substantially different fields, or from his Assistant Director, who is concerned with the total DEFENDER effort. But essentially the technical manager is alone, except for the part time assistance of administrative and clerical personnel.

This central role of the individual, usually overworked, technical program manager is difficult to overemphasize. His ability personally to build a case for supporting a new proposal (essentially needing to "sell" only his office Director and the ARPA Director) underlies the flexibility and quick-response, essentially non-bureaucratic reputation which ARPA has enjoyed over the years. On the other hand, the technical manager's heavy workload and lack of support also helps account for an ARPA reputation for crisis management, loose management procedures and inadequacy in evaluating existing programs, particularly efforts of second-order priority. In retrospect, Ruina concedes that there were no formal evaluation procedures and he attributes it primarily to the short tours of duty of Directors who consequently never see anything through to conclusion.[22] He is much less tolerant of the criticism that ARPA technical program managers were often too busy to read the output of their contractors, i.e., they did not know in many instances what they were getting for ARPA's money: "Those things that weren't read, we knew weren't too important."

The 1962 DEFENDER study also reveals how "thin" the line of central program management in Ruina's ARPA had become:[23]

> ... a situation exists in Program Management, where only one man is now assigned to provide full time support for and keep abreast of the entire

> $100 M/yr. DEFENDER effort. Just the administrative functions involved in preparing ARPA Orders and maintaining clear fiscal channels are sufficient to occupy him fully. His field contract with agents involved in DEFENDER, as a result, average only one visit per nine months, and first-hand visits to major contractors are extremely rare. There is little or no time available for him to perform the essential management audit functions, i.e., unbiased and timely evaluations of project accomplishments, measured in terms of progress against cost and schedule targets set forth in approved project plans. This means, in turn, that there is little or no real-time status reporting or 'early warning' capability outside of the technical project offices....
>
> There are several apparent difficulties with the reporting and control procedures now used by ARPA, and many are directly traceable to the small staff employed by Program Management. For example, this department has neither the manpower to collect data and prepare detailed reports, nor the time to analyze and substantively comment on those reports now received from external sources. It is also so completely occupied with administrative actions that it cannot maintain close liaison with contractors and agents, thus having little or no 'early warning' of pending program (as opposed to technical) trouble. As a result, it becomes involved in the management of a project only after a crisis has developed and a 'quick fix' is required.
>
> This is a fundamental problem; it cannot be resolved merely by changing the contents or format of ARPA's reports because no one in Program Management has the time to analyze, verify, knowledgeably criticize, or otherwise use them in a substantive way.

Again, these comments applied equally to Program Management's responsibilities vis-a-vis offices other than DEFENDER, and the problems raised continued long after Ruina's departure.

The small management staff, the study asserts, made it impractical for ARPA to be a leader in innovative program management techniques, such as the Navy's Special Projects Office had been with the PERT system:[24]

> Some of the more recently developed management techniques, such as PERT, would appear to have applications only to those ARPA projects that:

a) are large in size and involve a number of agent and contractor interfaces;
b) have readily identifiable events and objectives as opposed to being continued level-of-effort research; and
c) involve agents generally responsive to ARPA requirements, since at the present time the ARPA staff is probably too small and too busy to make use of even a summary PERT network.

It would appear, moreover, that the use of such techniques should be left to the option of ARPA's agents since, at least at the present time, ARPA does not have the internal staff of the size needed to make full and substantive use of the information that would be forthcoming.

In fact, ARPA was to maintain a consistent focus over the years in using straightforward, available management approaches rather than attempting ' ovation, the exception being greatly increased use of computer assistance in the 1970's (closely coupled with developments coming out of the information processing office). To the extent that ARPA innovated managerially it was in the realm of using existing techniques such as no-year money, unsolicited proposals, sole source procurement, multi-year forward funding, etc., as imaginatively and extensively as possible in order to minimize the red tape burden itself and underwrite its record as a quick response agency. Ruina encouraged this, coming, as he said, from an academic background where "the people tended to be more imaginative and less responsible" and having at that time "much less respect, perhaps, for proper bureaucratic behavior ... than I do now."[25] Ruina felt strongly that in basic research, accountability to the peer group was much more important than accountability to the contracting officer.

Turning to the interface between ARPA and the Service agents performing the actual contracting tasks, the 1962 study defended the system in concept, but noted numerous problems:[26]

Problems mentioned during our field surveys by the agents as well as by ARPA personnel indicated that there is room for improvement.... The agents, for example, often considered ARPA work to be an additional requirement for which they received neither personnel authorization nor compensation for the salaries of personnel assigned to ARPA activities. They felt that, in many cases, the ARPA Orders came down to them in the form of directed sole source procurements, without the necessary backup to comply with ASPR or service

> regulations and without any freedom in the scope of work for the agent to contribute or to exercise technical judgment. As a result, the agent often viewed himself as a mere processor of formal documents, and therefore had little incentive to apply unusual effort or to organize in a special way for the management of ARPA work. There was a corresponding feeling among the agents that ARPA had no valid right to expect unusual treatment or to expect that agent personnel would be willing to put ARPA interests ahead of the interests of their service, which would ultimately be responsible for their individual evaluation and career progression.
>
> ARPA, in turn, has objected to long lead times and indifferent support at the agent level, as well as the apparent efforts of some agents 'bend' the scope of work toward their parochial interests or to take over the ARPA program altogether.

These problems also were to persist over many years, but in the context of greatly varying roles for specific agents (from full contract technical control to purely administrative housekeeping) and levels of performance (from highly enthusiastic contracting agents fully integrated into the technical program, to disinterested agents, to agents striving to reorient their contracts for their own purposes). The 1962 DEFENDER study recommended experimentation with certain incentive techniques, which in their specifics were not well accepted at the time, but ARPA did experiment over the years with specially "dedicated" agents. The most notable example here is the development of a group at the Army Missile Command (AMICOM) at Huntsville, Alabama, which was devoted exclusively to ARPA contracts (primarily DEFENDER) and has received very high marks from ARPA officials for its performance over the years.

On balance, however, the mixed performance described in 1962 appears to be quite representative of the workings of the agent system. Its most positive feature in the eyes of most ARPA observers has not been the uniform excellence of Service agent performance, but rather that the system has allowed ARPA to forego creation of its own bureaucratic contracting structure and has provided flexibility through ARPA's ability to select agents in line with such considerations as ultimate program transfer.

Gen. Betts had found the executive agent system a great burden. Observing ARPA from his Air Force and DDR&E vantage points Ruina had felt that ARPA "was being taken ... the Services always put their own English on the ball." As Director of ARPA he found that the system could not be overcome. Ruina felt that to get quality scientific results, programs had to be tightly controlled; too often, control was lost once a program was released to the agent. He never liked this system and concluded, in retrospect, that if he had been in Roy Johnson's shoes, he might have insisted on his own contracting unit.[27] Charles Herzfeld, who defended the agent system throughout his directorship of ARPA, has subsequently come to agree with this position in the light of growing rigidity in Service contracting procedures.[28]

The DEFENDER study also addressed a number of other management questions in a fashion which by and large supported established ARPA positions. It concurred, for example, in the decision not to have ARPA laboratories* (viewing contracting to strong groups such as Lincoln Laboratory as more efficient and flexible); agreed that ARPA's advanced research mission required that it be able to use sole source contract arrangements (which required in 1962, as now, a specific exception from procurement regulations in the form of a "determination and finding" exempting the class of research undertaken by each Service for ARPA); and opposed a move toward reliance on either internal or OSD contracting. The study's primary recommendation, which was never accepted by ARPA, was to enlarge staff support for project planning and technical direction (either in-house or through contracting) and to develop a strong program review and evaluation group. ARPA was to remain throughout Ruina's period and thereafter a very thin management organization, a fact viewed by many as an asset, but which created problems for almost every successive Director, reflected through critical DOD audits, GAO reports and Congressional hearings.

PROGRAMS IN THE RUINA PERIOD

As noted above, ARPA's program in the Ruina period emphasis tended to reflect two criteria of worth: importance in terms of (1) national policy concerns, and (2) the perceived needs of the scientific community. Sometimes these criteria were mutually reinforcing, e.g., achievement of a nuclear test detection capability and general upgrading of seismology and geophysical science. Sometimes they were poles apart, as with the AGILE program which sought to attract R&D talent to deal with counterinsurgency, but did not pretend to be addressing great scientific questions.

The coexistence of these two criteria helps to explain why the Ruina era is remembered both as the formative period for some of the Agency's greatest achievements of value to the Defense Department and as the time during which ARPA became imbued with the scientific community's basic research values and philosophy.

Dr. Ruina's ARPA averaged about $250 million in annual appropriations. DEFENDER accounted for approximately half of this total, followed by VELA,

* Ruina was prepared to break with this bit of holy writ, but Lincoln Laboratory resisted his overture that it become the national ballistic missile laboratory, under ARPA sponsorship.

Materials Sciences and AGILE as major programs (see Figure V-1). These and ARPA's other assignments of the early 1960's are described in detail below. Ruina did not strive to acquire new programs, with the exception of a short-lived interest in establishing an electronics research program on the model of the IDL effort; however, it was undercut by fears of potential competition with the previously established joint-Services electronics program. The programs in this period, therefore, are dominated by previously established assignments, supplemented by some staff initiatives (most significantly AGILE) and a few key assignments from DDR&E (notably research in penetration aids, command and control, and behavioral sciences).

DEFENDER

When Ruina became Director, the DEFENDER program was a rather sprawling effort composed of six functional elements: General Research; Discrimination and Identification; Interception, Guidance and Control; Kill Mechanisms; Detection, Acquisition and Tracking; and Systems Evaluation and Models.

As stated in a contemporary program description,[29] General Research comprised: "all the supporting research for the various ballistic missile defense programs." Specific projects included the controversial Arecibo 1000 foot radar observatory, hampered by a construction workers' strike at the beginning of the year and, surprisingly (for a "supporting research" category), the ESAR phased array radar. The program involved considerable experimental and theoretical research in universities and various research institutions.

Discrimination and Identification (later renamed Missile Phenomenology) was intended "[t]o observe missiles during their flights for the purposes of determining useful phenomena which occur during the missile trajectory and to design, develop and investigate techniques to accomplish discrimination."[30] In late 1960 and early 1961 this area of DEFENDER work was in transition from the early measurements programs to the major new Project PRESS effort. As of April 30, 1961 design of the PRESS facility was about 95 per cent complete and Lincoln Laboratory was firmly established as scientific director for the undertaking. About $6 million was devoted to Project PRESS in FY 1961 and about $16 million in FY 1962, reflecting the acceleration of construction. In the interim the DAMP ship measurements program continued, with significant data collected on Titan nose cone signatures in early 1961. With the build-up of other measurements capabilities, two specially instrumented aircraft were transferred to the intelligence community.

In the spring of 1961, Interception, Guidance and Control was just a shell for a planned program. Some studies related to advanced interceptor technology were initiated at the beginning of the new fiscal year (FY 1962). The program developed slowly, however, and crystallized into a major highly-publicized effort (the HIBEX program) after Dr. Ruina's departure in the fall of 1963.

Figure V-1

PROGRAM BUDGET HISTORY DURING THE RUINA PERIOD
($ millions)

	FY 1961	FY 1962	FY 1963	FY 1964
Appropriations Requests	215	186	257	280
Actual Budget	215	186	250	274
Commitment to Agents	207	219	285	280
Requests By Program:				
Military Satellites/Space	67[1]	-	-	-
DEFENDER	110	104	110	128
VELA	-[2]	37	63	52
Materials	17	17	22	21
Propellants	17	18	23	25
AGILE	-	-	18	26
Energy Conversion	-	5	5	6
Climate Modification	-	3	2	-
Toxicology	-	.8	-	-
C&C/Information Processing	-	-	9	13
Arms Controls	-	-	-	1
Behavioral Sciences	-	-	-	3
Technical Studies	-	-	5	7

[1] Transferred to Services under Betts.

[2] Approximately $40 million added for VELA after initial appropriations request.

Source: ARPA budget tables.

Kill Mechanisms was described as an effort to: "define more clearly the kill capabilities of the mechanisms now relied on for destruction and to discover techniques of greater effectiveness."[31] The two major areas of investigation under this program were directed toward non-nuclear methods of killing an incoming warhead: (1) direct "hypervelocity" impact of, say, particles or fragments, and (2) the previously discussed charged particle beam concept, still regarded as a far-out possibility.

Detection, Acquisition and Tracking included various projects related to phased array radar component development, the development of a 50 megawatt S-band radar and a modest program in over-the-horizon (OTH) radar development. OTH received increased attention later and was continued in the ARPA program in modified form until 1975.

Systems, Evaluations and Techniques included the controversial BAMBI studies of boost intercept systems, the ARPAT terminal defense system study and feasibility study of a system known as HELMET, which was based on hyper-velocity impact technology.

Ruina arrived in ARPA grossly dissatisfied with the structure and content of DEFENDER, which remained essentially a carryover from the original IDA design:[32]

> It was rather clear that our little [3 man] staff in DDR&E in Air Defense ... just knew more about what the needs were ... for the BMD program, and were totally unimpressed with the way the program was structured, what they were supporting, and what they were doing. A lot of the staff in ARPA I thought was quite good, but the leadership there just wasn't with it on this program.

He felt that DEFENDER had tried to be too comprehensive, to fill all the gaps, and to have all the "next generation" programs. This was a fair comment, but unfair criticism in the sense that ARPA's original BMD mission was precisely to be comprehensive and to cover all the available ideas so as to leave no stone unturned and to prevent the Services from running off half-cocked with some allegedly "neglected" idea. Ruina decided to change that. In particular, he felt DEFENDER should neither be systems oriented nor do any systems work. Rather it should be carried on just as basic research was done:[33]

> DEFENDER is not systems oriented nor should any systems work be done within the DEFENDER Project. Systems are too pretentious; ARPA should only think in the broadest of concepts of systems, for planning purposes perhaps but nothing else. The ARPA program must be kept oriented toward the research and not the development.

Within a year, Ruina had made significant changes in DEFENDER's program structure. Four program categories emerged: General Research, Techniques and Devices, Missile Phenomenology, and Systems. The major effect of this change was to merge the smaller research efforts in Interception, Guidance and Control, Kill Mechanisms, and Detection, Acquisition and Tracking into a single Techniques and Devices category; and to shift several specific projects between this and the other three offices. For a time this reorganized program was divided between the newly-recruited Dr. C. M. Herzfeld and the former DEFENDER program head, but was soon consolidated under Herzfeld.

The Deputy Director, Dr. Rathjens, was as critical of DEFENDER as Ruina, describing three-quarters of its work as "crazy:" there was "crazy work going on and crazy proposals coming along."[34] He recalls that he and Ruina had to be very tough about that and concedes that their attitude initially caused morale problems. Nevertheless "DEFENDER was a godawful mess in terms of the kinds of things being supported"[35] and changes had to be made. Herzfeld also shared the Ruina/Rathjens evaluation of DEFENDER, in most respects:[36]

> In the early days before I came in, it [DEFENDER] got ... very wild and irresponsible I would say. And [to] where goals were also kind of confused. It had bad management for a number of years. I was hired to straighten that out. I think I did. We based our stuff on good measurements and good theory, going all the way from the laboratory and small scale simulation to full size experiments ... full size missiles and full size radars and all that.... [A]nd we tried to do that with every major idea.... Whatever we said was defendable in terms of rather detailed scientific backup and therefore people couldn't very well argue with it. I think that this was the strength that the program got.

There was a great urge, often implicit, to shed the Johnson era image of reckless and cavalier pseudo-science that was shared by many in DOD and the White House.

The DEFENDER reorganization reflects Ruina's tendency toward administrative simplification, but also appears to have been designed to reduce the visibility of certain efforts or at least to place them in a context perhaps less likely to create misunderstandings. The charged particle beam program, for example, was shifted to General Research alongside other long-term fundamental research efforts and away from the highly visible Kill Mechanisms branch. The hyper-velocity impact part of "kill mechanisms" was buried in Techniques and Devices, as was laser research, another subject that was to stay with ARPA to the present day. These actions did not necessarily imply distaste for the projects involved. Indeed, for Ruina the particle beam project was "an example of a good or ideal" ARPA project:[37]

> There will not be any payoff; it is not practical but there are many good people assigned to it; there is much knowledge being developed from the effort and it permits freedom of work in a research or laboratory atmosphere.

But if such projects were to be supported on grounds of scientific merit rather than likely defense relevance, Ruina did not want them bandied about as practical systems promoted by enthusiasts as near-term alternatives to missile-based BMD.

Similarly, in the October 1961 Systems category description, the BAMBI and HELMET projects are given clearly secondary priority to ARPAT, which had the more modest objectives of developing an experimental radar and experimental interceptor, in addition to offering a major new systems concept. Ruina was especially hostile to BAMBI, which he felt was "stupid," neither a good idea nor a good system:[38]

> I always thought that it was a looney idea. I don't know why we continued it..., BAMBI brought in all the nuts out of the woodwork.

One reason for continuation was pressure from the Air Force and politically influential supporters such as Simon Ramo. Nonetheless it was a measure of ARPA's growing strength that it was able to reduce the BAMBI level of effort, phasing it out by 1963. ARPAT, an idea strongly promoted by Dr. B. Alexander, was supported by Herzfeld (then DEFENDER director) because it provided a not completely far-fetched alternative to the NIKE-ZEUS/NIKE-X approach (using air-borne rather than ground based interceptors). Herzfeld considered ARPAT "kind of nutty," but believed there was a need to support at least one radical alternative to distinguish DEFENDER from the Army program.[39] In addition, and perhaps more importantly, APPAT contained some highly-interesting technology development work, notably interceptor homing technology and radar development. The interceptor homing technology work is said to have produced the first prototype "electro-optically" guided weapons and contributed substantially to later Army research in thie field. The radar work, predominantly development of the ARPA Measurements Radar (AMRAD), added to the Agency's wide-ranging program in this area. AMRAD was designed to utilize "multi-purpose coherent waveforms" for missile discrimination and analysis, and was used extensively in both BMD research and in analyses of "flight articles" in the U.S. offensive strategic missile inventory. As a system, Holbrook has confirmed that there was a "feeling" that somehow ARPAT would not work, but since "we couldn't shoot it down"[40] and there were promising technology advancement benefits, ARPA pursued it. Nevertheless this "interesting science and technology" cost roughly $40 million and produced no system.

Two new systems studies of a less "far-out" nature also were added to the Ruina DEFENDER program, one examining defense responses to sea launched ballistic missiles and the second examining hard point (e.g., missile silo) defense systems, a subject which only ARPA was willing to support.

In any event all systems concepts were analyzed more intensively than in the past and many, like HELMET and BAMBI and other GLIPAR program ideas fell by the wayside:[41]

> This is not merely a criticism of prior administrations. It simply was that the time had come to do these things and ... weed out the good stuff from the bad stuff and get rid of the irrelevant.... We had to get rid of I would say maybe twenty to thirty major potential ideas which were invented on the back of an envelope by bright and inventive people, and everybody was trying to think up better solutions than [systems based on] radars and missiles. And practically none of those survived that screening.

By and large, Ruina and Herzfeld went back to "radars and missiles."

Indeed one of the most obvious features of DEFENDER in the Ruina period is the prominence of radar development work. The Techniques and Devices branch was the home for much of this work, but major radar development programs could be found everywhere. ESAR and Arecibo were multi-million dollar radar programs under General Research. AMRAD was a major investment in Systems. Missile Phenomenology provided a home for the huge continuing expenses of the TRADEX instrumentation radar and its later follow-ons. ARPA continued to pioneer in the development of phased-array radars which directly influenced a whole new generation of advanced Service radars. It built some of the best (and most expensive) radars based on current state-of-the-art technology and they revolutionized capabilities for research measurements. It made substantial investments in radar components which have had a difficult-to-trace but profound influence on the field at large. It put sizable funding into special-purpose radar facilities such as the Arecibo radar/radio telescope and into new radar applications like the over-the-horizon radar. Multi-million dollar radar systems funded over the years include ESAR, PINCUSHION, TRADEX, ALTAIR, ADAR, ALCOR, HAPDAR, ARECIBO, and numerous others. The total ARPA investment in radars is virtually impossible to calculate, but by the mid-1970's easily totalled over one-quarter billion dollars solely for direct investments in radar technologies. The amount of ARPA research dependent in one way or another on these developments must total at least one half billion dollars (PRESS alone amounted to over $250 million) and could be perhaps as high as one billion dollars, depending on how one wishes to categorize the "related" research effort. As Herzfeld summed it up: "We were the major funder over all the years I was there, of radar technology including sort of everything about it."[42]

Emphasis on radar development was, of course, part of the DEFENDER effort before Dr. Ruina became ARPA Director. Indeed, almost any form of ballistic missile defense was conceptually dependent on radars;* hence an advanced BMD program virtually by definition was an advanced radar program, in large measure. Dr. Ruina, moreover, came to ARPA with a background in radar and gave new impetus to ARPA's preeminent role in creating what Alexander has called the field of "modern radar;" according to Alexander, prior to ARPA's work, all R&D on radars had been limited to attempts to make incremental improvements of a mechanical nature in World War II radar models.[43] In this regard Ruina's paramount emphasis on research quality was reflected throughout the program, particularly in supporting and expanding the role of Lincoln Laboratory despite many administrative disputes between the Agency and Lincoln. Ruina was also quite influential in expanding the ARPA effort in modern radar "signal processing," i.e., in developing sophisticated methods to derive the most information from radar capabilities rather than relying heavily on high power levels per se.**

Heavily dependent on developments in instrumentation radars and technically managed by Lincoln Laboratory, the PRESS reentry measurements program began under Ruina to occupy the central position envisioned in the Betts period. Work proceeded rapidly in constructing the infrastructure of the Pacific range facility and it was nearing full operational status by the end of the Ruina period. The importance of PRESS was underscored in Dr. Ruina's reorganization. By reducing the number of DEFENDER branches, the Ruina reorganization highlighted Missile Phenomenology, which was increasingly dominated by PRESS. Since both "general research" and "systems" tended to be supporting offices (the former providing a research base and the latter conceptual frameworks relating to the other office missions), Techniques and Devices was the other core DEFENDER office. Missile Phenomenology, however, had a much more defined purpose than Techniques and Devices, which comprised in essence "everything else." In budgetary terms, Missile Phenomenology was clearly dominant among the DEFENDER program. FY 1961 funding for DEFENDER was:

* Except highly exotic "shield" and random kill concepts and, in principle, systems based purely on optical means of locating and discriminating hostile missiles. These were always highly remote possibilities.

** E.g., the AMRAD contribution was largely in serving as a test bed for sophisticated signal processing techniques.

Missile Phenomenology	-	$ 77.3 million
Techniques and Devices	-	30.0 million
Systems	-	11.9 million
General Research	-	9.3 million
Total		$128.5 million

In late 1961 the complexion of DEFENDER changed further with a major new assignment from DDR&E relating to offensive missile penetration aids technology. This assignment completed the basic content of the DEFENDER program as it would exist for the next seven years.

DEFENDER had a few "down" moments under Ruina. York, for instance, once cut $40 million out of the DEFENDER budget -- a one-third reduction -- because of a negative PSAC comment about the program's organization. Ruina successfully talked him into restoring most of the funds.[44] Indeed it may be very significant that Ruina, with his strong ties to PSAC, was Director of ARPA because PSAC tended to become rather negative about missile defense in the 1960's. Someone unknown to PSAC, given the Roy Johnson legacy, might have found it very difficult to defend the program. Ruina recalls discussing the possibility of eliminating DEFENDER, "a little," with both York and Brown, but the program was never in real jeopardy. The basic question was whether "the unattractiveness of ballistic missile defense is based on such simple information that was available at that time that we wasted a lot of money anyway."[45] Interestingly, Godel takes the view that the scientists had convinced him within six months of ARPA's creation that an effective BMD system could not be invented,[46] and Holbrook insists that every BMD idea of value was identified in 1957-58.[47] Why was this work continued? Ruina explains it cogently in these terms:

> Herb [York] and I would discuss 'why do we have a BMD program at all?' Here we are: we know this ABM thing has a fundamental limitation. We are not going to be overcome by any simple gadget. Why do we do this at all? It was costing a fortune, you know -- ARPA, $100 million plus, the Army $300 million plus. Maybe it was the rationale, but I think we believed it. One, if I do this work, we would be on top of the ABM technology in a meaningful way, because we always thought the Russians would be deploying an ABM. As I remember, we wanted to have the option, if the political and technical situation changed: if we want to build one, we ought to build the best one we can.

The Sputnik demonstration, matched with continuing concern over Soviet intentions, had a powerful carryover effect. Nonetheless, Ruina is basically in tune with the sentiments expressed by Holbrook and Godel.

Asked if DEFENDER had failed to explore any promising ideas, he responded: "Jeez, I think it overexplored everything ... since we have nothing now, and think nothing is good enough."[49]

If it was necessary to do BMD work at all, however, there was no doubt in Ruina's mind that an ARPA program was essential:[50]

> All the other programs -- Air Force or the Army -- would have done the whole thing a tremendous injustice. The Army had interest in only developing a system for procurement.... The Air Force was still in its Buck Rogers period, and the stuff they were pushing in ballistic missile defense was absolute garbage. You know, radiation weapons, BAMBI.... They picked up the most exotic, most outlandish, most remote, most Buck Rogers programs which somehow matched their fantasies of what the Air Force of the future should be like.

In essence, neither Service would undertake the hard and sometimes mundane but difficult work done by DEFENDER: "The Army said that there was no problem and the Air Force pictured a guy in outer space."[51]

Ruina's DEFENDER philosophy therefore was that ARPA could play the role of the objective "honest broker." It would undertake the careful work in reentry measurements that was necessary to assess BMD possibilities (and offensive systems vulnerability to BMD systems), would support quality technological development work in radar and other fields likely to be overlooked given Service procurement orientations, and would serve as an expert critic of Service proposals relating to BMD. In addition, a cornerstone of the DEFENDER rationale was that it would provide a rallying point or gathering place for an expert technical community outside of the Services, and this community was felt to have a value beyond its performance of narrow tasks on specific projects. The development of this technical community, highly praised in retrospect by Dr. York, was brought to maturity during the Ruina directorship and played a significant role in the evolution of defensive and offensive strategies throughout the 1960's.

<u>The Penetration Aids Assignment</u>. The assignment of research responsibilities in Penetration Aids (Pen Aids) was made by the DDR&E, Dr. Brown, in October 1961. Specifically, ARPA was instructed to make available to the Weapons System Evaluation Group (WSEG) "information on the physical properties of existing and programmed U.S. ICBM reentry vehicles" in order to assist in a continuing WSEG evaluation of the "performance of ballistic missile systems against terminal defense."[52] In addition to providing these inputs to WSEG, however, ARPA was given a much broader responsibility:[53]

> Beyond the specific information required for the analysis, however, I desire that you maintain a sufficiently broad base of investigation of the physical properties of existing and programmed U. S. ICBM re-entry systems to develop a comprehensive picture within ARPA of the following:
>
> a. Lethal radii of possible defensive weapons against the re-entry vehicle or vehicles.
>
> b. Physical properties of re-entry vehicles to include shape, weight distribution, and radar cross-section as a function of orientation, polarization, and radar frequency.
>
> c. Behavior of r/v and decoy physical observalbes during re-entry.
>
> d. Penetration capability of the system against various possible AICBM systems.
>
> In addition to these efforts, I expect you to develop a broadened program which will include applied research on penetration and decoys.

This assignment was a substantial addition to the DEFENDER charter because it provided explicitly that ARPA's work in missile phenomenology would henceforth be directed toward strategic offensive systems applications as well as BMD systems applications, and that ARPA had an additional charter to do direct research on penetration aids and decoys. With this assignment, DEFENDER was clearly authorized a broader role than advanced ballistic missile defense research.

In many respects this DEFENDER "add-on" falls in the mold of previous "Presidential issue" assignments. As a result of the work of PSAC's Ad Hoc Panel on Warhead Vulnerability and internal DOD study of the problem, the new President and Secretary McNamara became quite concerned about the ability of our warheads to penetrate future enemy BMD systems.[54] They became aware of the large inconsistency in thinking about pen aids, namely that not building an ABM system was being justified in part on grounds that it could not cope with pen aids, while on the offensive side the Air Force was then not interested in pen aids. Accordingly the Secretary informed the three Service Secretaries that he had directed the DDR&E to carry on a continuing performance evaluation of all offensive missile systems, using ARPA where necessary to monitor or initiate new research. Dr. Brown's October instruction put ARPA squarely in the picture. As Herzfeld has explained it:

> [E]verybody got very annoyed with that very unsatisfactory state of affairs, and said 'let's get it all together.' And they made it very clear that they expected me to get it all together and to get it together in a great hurry.

It was a potentially volatile situation because assessments of the penetrability of the various missile systems would bear heavily on the Secretary's decisions about the balance of forces. General Betts, for one, gives ARPA high marks for its performance:[56]

> [T]he best early work on pen aids, from a creative point of view -- ideas and capabilities -- came out of the ARPA guys who were working in the DEFENDER program trying to figure out ways that DEFENDER could be defeated as well as ways our own offense could be stronger.

Given the importance of this assignment to DEFENDER, Dr. Ruina's memory of the event is somewhat surprising: "I do not recall ever having ARPA-sponsored work on the offensive side during my period."[57] When he was reminded of the Pen Aids assignment, he still failed to recall any details. This failure of recollection may relate to Ruina's preoccupation with other DEFENDER matters during this period and his personal advisory role in DDR&E on BMD issues in general. Prior to coming to DOD, he had been associated with radar development and since the capabilities of new advanced radars were a primary factor in the NIKE-ZEUS decisions, it is quite likely that he gave considerable attention to DEFENDER's developments in this field. Moreover, the Penetration Aids work was closely related to the measurements program, which he regarded as "necessary but not exciting."[58] Reflecting his lack of emphasis on Pen Aids, Ruina does not mention the subject in either the FY 1963 or FY 1964 Congressional appearances. Viewed from another context, this incident may also reflect the strong Ruina relationship with DDR&E. He was accustomed personally to receiving important questions and tasks from Brown; this was simply another one.

Herzfeld, whose first task as a member of the ARPA BMD office literally was to "staff" a draft copy of Harold Brown's Pen Aids directive with senior levels of the Air Force, definitely was impressed by the possibilities which this assignment presented and penetration aids research became firmly established in ARPA during the Ruina period. In FY 1962 $5 million was programmed for it and it continued to expand to as much as 15 per cent of the total DEFENDER budget, excluding considerable funding in the missile phenomenology branch which in fact provided measurements data as valuable to offensive problems as to the defense.

One of ARPA's Pen Aids tasks was to keep a running status report of how well U. S. offensive systems could be expected to perform:[59]

> This in turn led to the need for a very tight updating of the understanding that was available of offensive/defensive interaction, technolcgy, systems, hardware. This in turn led us to publish ... compendia of U. S. systems with all the things mentioned that mattered for being able to penetrate. Like what radar cross-sections, what hardness, what flight profile ... all this stuff.... That study demonstrated to everybody that there were great problems and also made some suggestions about how to find out what the problems were and how to fix them.

The import of the Penetration Aids assignment is recognized in ARPA testimony only in the post-Ruina period. In the FY 1965 House Appropriations hearings Dr. Sproull describes DEFENDER as "a broad program of research and exploratory development in the field of ballistic missile defense and penetration aids."[60] Secretary McNamara's testimony for the same hearings is also very explicit. DEFENDER, he said, was:[61]

> ... concerned with the development of the scientific and technical knowledge needed for the design of U. S. defense against ICBM's and IRBM's and for the assessment of the ability of U. S. ballistic missile systems to penetrate to their targets.... About half of the amount requested for DEFENDER will be devoted to the study of missile reentry phenomena.... This work will be particularly helpful in defining the Army's NIKE-X development program. It will also be important for the Air Force and Navy programs concerned with the development of penetration aids for our strategic retaliatory missiles. (Underline added.)

The Department appealed against a proposed $17 million Committee cut in the total ARPA budget primarily on the ground that apportioning a share of the cut to DEFENDER would delay "the most sophisticated penetration aids believed technically feasible." By the FY 1968 hearings, Dr. Herzfeld describes DEFENDER as:[62]

> ... that branch of ARPA charged with the responsibility for research and exploratory development to provide the basis for the ballistic missile defense of the future. Because defense and offense are opposite sides of the same problem, Project

> DEFENDER's mission and activities also contribute in an important way to the development and improvement of our strategic offensive weapons.

He claims, moreover, that:

> ... the DEFENDER program and its people have helped the military departments in developing their ideas and their hardware for the improved penetration capability which Mr. McNamara has brought before the committee and which is essential for us to maintain our assured destruction deterrent capability. I view our contribution to the penetration capability of the military systems as quite considerable and quite directly traceable.

Herzfeld is very assertive about ARPA's Pen Aids achievements:[63]

> It was clear, first of all, you had to get straight what the matters of fact were and then you had to get straight what facts mattered. Then you had to get a program of R&D to fill any big gaps in knowledge and to get some solutions. And then we had to affect the systems that were being built and deployed. So you can think of phases, if you like. You know, it's pretty clear what had to be done, and that in fact is what happened. The MINUTEMAN and POSEIDON are different because of what we did then or started then in '61.

At the same time, he is rather realistic about the events that triggered the original assignment:[64]

> Q: Was the interest in getting Pen Aids going on an accelerated basis kind of a 'missile gap' situation, where we worried about the Soviet ABM system?
>
> A: Absolutely, and we were overly worried. The gap was self-invented. The Leningrad System would have amounted to precisely nothing. However, had we gone on with MINUTEMAN I and POLARIS II we would now be in great difficulties, they would be vulnerable a lot. But the then-current threat turned out not to be a threat to our then-current and planned systems.

Thus Herzfeld sees the value of the Pen Aids work in a longer term context. It came to dominate his conception of DEFENDER. Indeed, in the days just before the DEFENDER transfer, with an increasing need to distinguish DEFENDER from the Army's NIKE-X program, the program is actually described as follows:[55]

> Project DEFENDER is a broad program in research and exploratory development by which ARPA seeks to advance the scientific and technological position of the U. S. in the fields of strategic offensive and defensive systems technology. (Underline added.)

Following the transfer of the main DEFENDER effort in 1968, the research assignments retained by ARPA are grouped within a Strategic Technology Office, explicitly described as a balanced research and exploratory development activity relating to both strategic offensive and defensive systems. ARPA's ability to move in this direction was considerably strengthened by the development of experience in DEFENDER outside of the narrowly-defined BMD field, which in turn was given impetus by the explicit assignment of non-BMD penetration aids research by the DDR&E in 1961.

The above discussion leaps ahead of the story to emphasize an important facet of the Ruina period in ARPA's history, namely, that major program areas have grown from assignments or project starts which at the time were not viewed as of particularly great importance. Pen Aids represents a rather substantial addition to the ARPA program developed from an uncontroversial and rather modest initiative.

The "Negative Value" of DEFENDER. One of the most difficult aspects of DEFENDER to assess is its "negative value," that is, holding major projects which would otherwise have been in the Services, providing a continuous critique of advanced radar and other sensor programs, and providing a point of resistance to pressure for premature, large-scale funding commitments. During the Ruina period, two primary examples are cited. The BAMBI program is given as an example of a specific project which was less susceptible to pressures for heavy investment in ARPA than it would have been in the Services. The development of broad sources of expertise which strengthened technical opposition to NIKE-ZEUS is an example of the more diffuse moderating effect attributed to ARPA.

The argument that ARPA's role in this respect was of major importance largely hinges on the assumption that without ARPA, expenditures of an order of magnitude higher might have been made. With regard to BAMBI, for example, it is argued that the Air Force and the primary contractor for much of the work (STL/TRW) were strongly pushing for a commitment to an orbital weapons system. Whereas ARPA spent perhaps $10 million over a few years to prove the concept impractical, it is argued that billions might have been spent if a decision had been made to pursue an Air Force operational system. Similarly, if the Army had attained its goal of deploying ZEUS, billion dollar investments would clearly have been entailed.

On the other hand, it is not completely obvious that the ARPA work was necessary in order to head off major systems investments on programs such as BAMBI and ZEUS. An early DEFENDER head argues, for example, that the probability of BAMBI ever being a cost-effective system should have been seen as almost zero from the beginning; and certainly York, Brown and Ruina were always very negative about the concept. Regarding the decision against ZEUS deployment, Ben Alexander -- a principle figure in the early DEFENDER program -- argues that even the Army and its contractors could see the fundamental limitations of ZEUS, and that the work coming out of the DEFENDER community simply served to put "another nail in the coffin," and to reinforce already negative feelings at the DDR&E and OSD levels.[66]

On balance, though one can argue in the abstract that the flaws in BAMBI and ZEUS were sufficiently obvious that large scale development would not have been undertaken in a purely rational world, it must be recognized that the DOD of the early 1960's was having a difficult time resisting both proposals. General Betts recalls the situation vividly:[67]

> The other big thing that I think DEFENDER did was to kill what was a growing push behind building a satellite ballistic missile defense system. That would have cost hundreds of millions, at least, if not billions.... But until ARPA really went after that program and dug into it well enough to define its capabilities, limitations and costs ... there was a great deal of push behind it and it was generating the typical inter-Service rivalry.

While it may well be that without ARPA a commitment to fully develop and deploy such systems would not have been made ultimately anyway, it does appear quite likely that considerable research and development expenditures prior to such a negative decision would have been tolerated, given the political environment. The mere fact that ARPA did not have a base of power and political influence leads one to believe that its effort was more manageable than alternative Service approaches and hence more subject to budgetary restraints. Similarly, ARPA's role as a technical critic of ZEUS may have been somewhat redundant, given pre-existing objections, but it reinforced McNamara's conservative view on deployment in a manner not likely to have come out of Service programs. It assisted the Secretary politically, if no other way, because he could point to DEFENDER in saying that other possibilities were being investigated seriously. Thus DEFENDER's role in the early 1960's appears to have been significant in maintaining a restrained defense posture in developing BMD systems, though it is impossible to state whether any disastrously wrong, multi-billion dollar commitments would have eventuated in its absence.

DEFENDER's Positive Role. It would be misleading to imply that DEFENDER was generally viewed in 1961-63 as a purely "negative" program. Many still felt that new and exciting approaches to BMD systems could be identified. Elan in the ARPA program began to build. In many respects, DEFENDER can claim a substantial share of the credit for the subsequent evolution of the NIKE-X system. It nurtured a large number of talented people separate from the Army-Bell Telephone Laboratory (BTL) group committed to the ZEUS system:[68]

> DEFENDER was extremely useful in keeping a small community of people involved other than the Bell Labs in ballistic missile defense problems, and it is that community which defined NIKE-X. Not the NIKE-ZEUS people. Those people resisted every step of the way. They never wanted an advanced interceptor. They never wanted discrimination problems looked at. They just wanted to build the goddamned thing and that's all. And therefore the only community that was involved in ballistic missile defense problems that was outside of Bell Labs was the DEFENDER-supported community.

York supports that summarization. He credits DEFENDER with doing the work that made it possible to replace ZEUS with NIKE-X, then SENTINEL and SAFEGUARD:[69]

> Now those, as far as I am concerned, never worked out, but they were better than where we started from. And the Army (and the Air Force might very well have done the same thing) was so wedded to a particular system, that those things which made NIKE-X really better than NIKE-ZEUS would have taken a lot longer to come along.

DEFENDER tended to identify unresolved problems and to support work in key technologies that might contribute to resolution of those problems. General Betts credits ARPA with important contributions:[70]

> [T]hey did produce a great deal of technology and certainly some of the most objective and clearly best studies that were done [regarding] exactly where BMD could do a job and where it would be defeated by offense.... Sam Rabinowitz ... Jack Ruina, Herzfeld, they all made very real contributions to an understanding that, I doubt, would ever have occurred if it had been left solely to the Army to generate, or solely to any other Service to generate.

Betts emphasizes the value of ARPA-generated technology, and even goes beyond York by asserting that "I don't think it [the ARPA technology] would have been generated if it had been left solely to the Army, in its effort to create a defensive system."[71] General Betts, who closed out his career as Army Chief of Research and Development, summed up DEFENDER's value in terms echoed by the majority of people with whom we have talked:[72]

> [I]n all honesty its greatest contribution is that we never made a massive commitment to building a ballistic missile defense system, because they produced technology that was available to everyone on both the offense and defense sides of the question, so that there was a lot better understanding across the board about what a defense system could or couldn't do.

Ruina was to commence the process of shaping DEFENDER in the service of that objective. Herzfeld, whom he brought in to direct it, served in that capacity into the Sproull regime and later became Director of ARPA, thus giving DEFENDER a measure of continuity in leadership probably not equaled by any other ARPA program.

VELA

The VELA program had been in existence only a little over one year at the beginning of 1961, but project organization had been fairly well defined. The organizational structure was linked to the nuclear test detection environments to be investigated by ARPA: (1) VELA Uniform, for detection of underground explosions, (2) VELA Sierra, for detection of high altitude explosions by surface-based instrumentation, and (3) VELA Hotel for detection of high altitude/outer space detonations by satellite-based instrumentation. These three program elements were also known by the more direct titles of VELA Underground, VELA Surface and VELA Satellite.

VELA Uniform was aimed at developing techniques and equipment necessary to detect, identify and locate a sub-surface nuclear explosion. In 1961 it also had the ambitious objective to:[73]

> ... provide the foundation needed to develop an optimum system for detection of underground nuclear explosions which could be used either unilaterally by the United States or in connection with an international control organization.

This systems objective was a source of conflict, because the United States had an existing intelligence system for underground test detection. In its early years, and well into the late 1960's, one of the major problems of the VELA office was to establish its credibility vis-a-vis the existing system and its considerable technical expertise. VELA promotion of any system that might be competitive with, or construed to undercut, the existing structure was frequently an issue of concern within the DOD, a point illustrated in a later chapter in connection with the so-called Large Aperture Seismic Array (LASA) program. In essence, what the Eisenhower and Kennedy Administrations seemed to want was a system completely independent of the intelligence community and using none of its assets.

Major components of VELA Uniform included:

(1) Funding construction of 125 standard seismographs to upgrade the seismic capabilities of a similar number of facilities located in some forty countries around the world. This "Worldwide Standard Seismograph Network" was not a dedicated test detection system, but rather was intended to increase knowledge of the seismic environment worldwide and underpin improved seismological research in general, as well as providing general improvement of test detection capabilities.*

(2) Supporting a broad seismic research program through various other government agencies and the universities. The U.S. Geological Survey and the Defense Atomic Support Agency were cooperating agencies, as well as the Services (notably the Air Force).

(3) Investigating the adequacy of seismic detection stations, including the "Geneva-type" stations recommended by the Geneva technical panel in the late 1950's and the improved stations recommended by the Berkner Panel on Seismic Improvement, as well as other station concepts.

(4) Conducting experiments including nuclear/chemical underground tests to advance the state of knowledge concerning the signatures of tests in a variety of environments and earth types (a major determinant of the strength of a seismic signal being whether the explosion was conducted in

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* A subsequent VELA program director evaluated this work in these terms:[74]

> In the early 1960's we put in a worldwide standard seismograph net. I constantly, even to this day [1975], am amazed at the intellectual daring that [took]. What seems to be a fairly dull job of putting in [over a hundred] seismic stations in a motley assortment of locations in universities around the world, and just putting in uniform instruments of known characteristics and sending a team of repairmen around every six months to tune them up ... you know, it seems like the dullest thing you can imagine. In fact, it was a very important thing.

hard rock, "tuff," salt, etc.). The program also included investigation of the "decoupling" effect associated with conducting an explosion in a cavity -- a procedure which was theoretically seen to greatly reduce the strength of seismic signals (and hence the probability of seismic detection).

(5) Development of a data analysis center, to abstract and disseminate technical information generated by VELA studies.

(6) Investigation of alternative methods and criteria for distinguishing nuclear explosions from natural seismic events.

In almost all of the above areas ARPA worked closely with a Service agent which represented the organization responsible for the national nuclear test detection capability pre-dating VELA. This organization had, in fact, been largely responsible for drafting the initial program concepts which were incorporated into VELA Uniform and had at one time expected to manage the program. Later it assumed it would essentially control the total program, with ARPA being basically a funding channel. The decision to give ARPA greater control and responsibility resulted from the need to give considerable public exposure to VELA activity during a time of international test ban negotiations and public debate on test detection capabilities. Having very strong technical expertise and having developed much of the assignment, however, the Service agency involved held considerable resentment over the adverse DOD decision and felt almost betrayed by the delegation of such major responsibilities to ARPA.[75] Now it had to serve ARPA.

While Dr. Ruina was a strong believer in the propriety of the assignment to ARPA and in its potential contribution to a test ban, he and others retrospectively admit that ARPA's initial expertise in the field was relatively weak. The agent's competence in seismology was, of course, evident to those in universities and elsewhere who worked in this field. As Ruina put it, they felt that they had basic "intellectual rights," and indeed, "from the point of view of internal government people, they are the greatest experts. Nobody in our place knew as much."[76] Dr. S. J. Lukasik likened the situation to a classic David and Goliath encounter, except that there was some suspicion that David (ARPA) might prove to be a "hacker."[77] Critics felt that it appeared as if the assignment had been given to a bunch of incompetents while simultaneously insisting that their work be placed in the public domain. On a purely technical basis, the "totally asymmetric relationship" between the two parties made for "a totally absurd situation."[78]

Ruina's efforts to establish the VELA program as an independent source of expertise thus encountered numerous bureaucratic problems throughout his tenure, a most serious issue being access of VELA personnel to sensitive classified data which was of key importance in establishing research requirements and priorities and avoiding expensive duplication of effort. The agent had been in the business a long time. It had competence, some money, data, and would be around for "the long pull." Ruina was very conscious that "we were all transients."[79] The tension between VELA Uniform and its prime Service agent was really not overcome until the comprehensive ban issue faded as a matter of national priority and the ARPA program was reoriented toward enhancing national (DOD) capabilities to monitor testing in the absence of a complete nuclear test ban.

VELA Sierra (surface detection of high altitude explosions) was a less extensive effort than the above. It focussed on research on various methods of high altitude test detection (light emission, atmospheric change due to radiation or debris, electromagnetic waves, etc.) and on the exploratory development of appropriate detectors. Optical and radio techniques development were the two main program elements.

VELA Hotel, the satellite-based high altitude detection program, was still in its infancy in early 1961. After overly-ambitious plans in this area had been rejected in 1959, a Joint Working Group (ARPA, Air Force, AEC, NASA) was formed to provide guidance.[80] In March 1960 a four-year $100 million plan was proposed by this group in which concurrent efforts of obtaining basic scientific data and testing prototype equipment for satellite-based detection was recommended. Following various modifications, ARPA submitted a proposed research and development plan to the Secretary and on November 4, 1960 a limited research and development program was approved.[81] Because of the relationship of the program to test ban negotiations, however, the State Department requested that the Committee of Principals for Disarmament take up the question of the extent of national support required for conducting VELA Hotel research and development. The issue of the scope of the VELA Hotel program was thus still unsettled at the beginning of 1961 and was receiving high level national attention.

The actual program initiated in the spring of 1961 included plans: (1) to fly some basic experiments on "pick-a-back" DISCOVERER flights (that is as secondary payloads on planned flights), and (2) to put experimental payloads on three ARENTS environmental test satellites (NASA CENTAUR vehicles).[82] A modest program of studies on satellite detection methods was also underway. ARPA hoped, however, for a considerably more ambitious effort:[83]

> The present program will provide experimental data to increase basic knowledge and understanding of the physical phenomena which affect satellite-based detection of nuclear detonations in space. This reduced scope program can be phased into a more complete research and development program which is needed to provide the basis for the space-based portion of an operational nuclear test ban control system, if a requirement for the system is established.

The more ambitious program was eventually established during Dr. Ruina's term and became one of ARPA's greatest success stories during the Sproull period.

Unlike the case of DEFENDER, Dr. Ruina did not immediately institute major organizational adjustments within VELA. The changes in VELA rather are measured in terms of substantive accomplishments and added responsibilities. Notable among the latter were the assignment of research efforts in the area of on-site inspection of underground tests (under VELA Uniform) and the approval of the high altitude nuclear test detection spacecraft program (under VELA Hotel). The spring 1962 ARPA Semi-Annual Report emphasizes VELA technical achievements and their implications and gives the impression of an extremely vigorous program beginning to attain the payoff from initial R&D investments.[84] The program's status appears quite similar to that of DEFENDER a couple of years later when research data on reentry phenomena began to flow in great quantity to fill in a previous near-vacuum.

The AGILE Assignment

In addition to the flurry of experimentation with new, basic research assignments that occurred during the Betts period, one other idea was hatched but left pending into the Ruina regime. Eventually called Project AGILE, it was to receive Presidential sanction and standing as a "Presidential issue," linger in ARPA for over a decade, and qualify without serious competition as ARPA's most controversial program. It carried neither the strategic systems flavor of the early space and BMD assignments nor the basic and applied research characteristics of Solid Propellants and Materials Science. Focussing on the problems of countering insurgencies in less developed countries, AGILE was ARPA's first major entry into the tactical arena, until then the private preserve of the military departments. It was an indirect entry -- AGILE's professed concern was with indigenous military units, not U.S. forces -- but as American involvement in Southeast Asia grew and deepened, ARPA found itself squarely in the middle of the strategy, doctrine, tactics, and politics of a U.S. air, sea and land war in Asia. It did not escape unscathed.

AGILE's roots are superficially easy to trace, but the soil which permitted them to grow is a more complex matter. One of the classic defense policy issues of the Truman and Eisenhower Administrations centered on the theory that continued reliance on massive retaliation with nuclear weapons would tempt opponents to nibble away in conventional conflict situations short of the type which would provoke us to launch a nuclear attack. Critics argued that the U.S. was unprepared to deal with such limited war situations and blamed Eisenhower's budget policies for these inadequacies. The Gaither Committee Report weighed in with a strong recommendation that the U.S. rebuild its conventional forces for limited war purposes, with the Middle East and Asia as the prime geographic candidates. Throughout the post-Korea War period "limited" conflict situations arose in large number -- for instance, Berlin, Quemoy and Matsu, Iran, Cuba, Nicaragua and Guatemala, the Congo secession, the U.S. landing in Lebanon, the Hungarian Revolution, Suez, and Laos and Vietnam among the better known -- thus adding credibility to the critics' claims.

Southeast Asia, in particular, became a focal point of concern. Truman commenced aiding the French in Vietnam in 1950. By May 1954 when Dienbienphu fell we were paying 80 per cent of the bill and cumulative U. S. spending had reached $4 billion. The containment doctrine was applied to Asia, as well as Europe, and by 1952 the Eisenhower Administration had embraced the domino theory in Southeast Asia, in a relatively pure form:[85]

> The loss of any of the countries of Southeast Asia to communist aggression would have critical psychological, political and economic consequences. In the absence of effective and timely counteraction, the loss of any single country would probably lead to relatively swift submission to or an alignment with communism by the remaining countries of this group. Furthermore an alignment with communism of the rest of Southeast Asia and India, and in the longer term, of the Middle East ... would in all probability progressively follow: Such widespread alignment would endanger the stability and security of Europe.

It was also felt that falling dominoes would jeopardize "fundamental U.S. security interests" in the Pacific and threaten free countries in the area that controlled supplies of strategic commodities. The National Security Council estimated that the communists would most likely seek to achieve domination there through subversion rather than conventional invasion. Thus the notion of limited conflict situations was further refined to specify subversive or insurgent warfare as a serious threat. The Vietnamese, Philippine and Malayan insurgencies were available as first hand evidence of the trend.

Of particular relevance to the future Project AGILE, the NSC had decided in 1952 that it should be a U.S. policy in Indochina to "Assist in developing indigenous armed forces which will eventually be capable of maintaining internal security without assistance from French units."[86] By the spring of 1954 the level of intensity of feeling about Southeast Asia had increased several fold. A special NSC Committee concluded that "the free world strategic position, not only in Southeast Asia but in Europe and the Middle East as well, is such as to require the most extraordinary efforts to prevent Communist domination of Southeast Asia."[87] The Committee recommended that extraordinary unilateral and multilateral measures be taken to hold Vietnam. Although the public was not informed, Eisenhower in fact came within an eyelash of supporting overt U.S. military intervention in the war.* Covertly, he sent Colonel Edward T. Lansdale and a team of experts to undertake unconventional warfare operations against the Vietminh while the Geneva Conference was in session (June 1954) and soon launched a program of military and economic assistance to the then-Premier Ngo Dinh Diem. The Administration also pumped about $300 million into Laos, most of it in support of General Phoumi Nosavan's right wing forces. On the diplomatic front, the Southeast Asia Treaty Organization was created.

Thus the U.S. Government, or at least decision-making levels in the Executive Branch, was moving strongly in the direction of immersion in local conflicts. While the depth of this propensity to become involved definitely was not public knowledge, nor even widely appreciated within government, it was very obvious to a number of people in foreign policy, national security and intelligence positions.

One such person was ARPA's Director of Policy and Planning, William H. Godel. Prior to joining ARPA, Godel had compiled a brilliant record in intelligence work and rose to GS-18 level in his early 30's. He was both a retired Marine Corps officer and a keen student of geopolitics. He had considerable personal experience in Southeast Asia, including membership on a mission to Vietnam headed by General Graves B. Erskine in the early 1950's where Godel was deeply impressed by what he saw happening to the French.

Godel concluded earlier than most that American foreign policy seemed set on a course that was bound to result in deep U.S. involvement in conflict situations completely different from those encountered in the World Wars and Korea. Specifically, he believed the Far East and the Middle East would become the combat areas of the future. He gave lectures to this effect at the War Colleges and elsewhere. The problem was "to learn to fight a war that doesn't have nuclear weapons, doesn't have the North German Plain and doesn't necessarily have Americans."[88] With respect to the latter point, Godel says that he was definitely affected by a remark that Diem once made to him: "The one way we lose is if the Americans come in here."[89] If the U.S. were not to intervene in force -- and many military men swore by the dictum that American armies should never be committed to a land war in Asia -- this would mean in most instances that it would be assisting indigenous forces who were faced with subversion and insurgency.

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* Interestingly, the JCS opposed such intervention on the ground that "Indochina is devoid of decisive military objectives and the allocation of more than token U.S. armed forces would be a serious diversion of limited U.S. capabilities." (Memorandum to the Secretary of Defense, Charles E. Wilson from Chairman, JCS, Admiral Arthur W. Radford, "Studies with Respect to Possible U.S. Action Regarding Indochina," May 26, 1954, published in New York Times, The Pentagon Papers, (New York: Bantam, 1971) 44.)

These were situations for which Godel realized the U.S. military was ill-prepared, either to fight itself or to teach others about. Based on the Philippine and Malaysian experience, he was convinced that U.S. doctrine and tactics would fail to match up with the people or the environments within which insurgent warfare would be waged. He was aware that the small U.S. MAAG group in Vietnam was intent on training and creating a Vietnamese military completely in the image of U.S. forces, i.e., division structure, road-bound, etc. Whatever the merit of criticisms of Project AGILE itself, it is difficult to fault Godel's anticipation of the future course of U.S. policy in Asia or its consequences for DOD.

Later, after he joined ARPA, Godel added a scientific and technological dimension to this scenario. It was, he said, simply a matter of "How do you define a piece of the problem within the segment in which you live?"[90] Living in an R&D world, Godel proceeded to tailor the problem to his bureaucratic surroundings and tried to do something about it. Intellectually, he integrated his understanding of the threat with his understanding of R&D. He believed that in most cases the insurgents would have superior discipline, organization, and motivation than their opposition. Perhaps, he thought (probably still infatuated with the "science can do anything" fervor of the outer space days) science and technology can give "our" side an equalizer. It was a simple, if bold, hypothesis.

In early 1960, as part of the search for a new role for ARPA, Godel persuaded the DDR&E to approve a lengthy trip to Asia for himself and the Deputy Director of Defense Research and Engineering, John Macauley. In part, the trip was based on Godel's assertion that since future wars were likely to be found in the Far East, it would probably become a problem area for R&D as well. York, according to Godel, accepted that rationale.[91] In part it was based on the notion, also long championed by Godel, that the U.S. should be much more aggressive in seeking out and supporting research and development capabilities in other countries and using technologies that they had developed. ARPA had let contracts in Europe and Israel related to space and missile defense research and it was argued that Japanese, Australian and other scientists might also be useful. A list of things to look at was prepared. DOD was then looking for a good polar satellite launch site and Woomera, Australia was a candidate.* Vietnam, Thailand and Indonesia were also included on the itinerary. The resulting trip report contained over forty recommendations and suggestions, covering nuclear test detection, BMD and other research areas. Among them was a suggestion that the Thai, Vietnamese and Australians were interested in developing and testing technologies suitable for coping with insurgent situations.

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* Australia was of particular interest to ARPA's BMD work because it offered the prospect of a 3000 mile test range entirely on land and thus was amenable to complete instrumentation, a requirement for study of the mid-course vulnerability of missiles. The Australian also had a drone ASW torpedo (Ikara) that looked promising.

Nothing much was done about the counterinsurgency recommendations initially, although Godel continued to press his views on people throughout government, many of them well-placed, via his remarkable network of contacts. These included people who were to play prominent roles in the new Kennedy Administration. Godel prepared detailed analytical papers for General Maxwell Taylor and Walt Rostow, for instance, on the unique nature of insurgency and the potential value of applying American scientific talent to the problem. The Kennedy prople rapidly became absorbed in Southeast Asian affairs. Initially Laos was the focal point; Eisenhower admitted when he stepped down that it was the most dangerous "mess" that he was leaving the new President. Kennedy spent more time on Laos than on any other problem in his first two months in office. Two weeks before Kennedy was sworn in Khrushchev made his famous speech pledging support to "wars of national liberation" and the Soviets had an active airlift into Laos. In the spring of 1961 direct U.S. intervention in Laos was a real possibility, including talk of placing a cordon of U.S. troops across southern Laos from the Thai border to Vietnam. Kennedy eventually rejected such ideas, but he did send a small U.S. unit to northeast Thailand in March 1961, followed by a 5000 man combat brigade in May, intended to show the flag and impress the Soviets. In June Walt Rostow told Secretary McNamara that it was time to think about a "guerrilla deterrence operation" in Thailand. Basic decisions to increase support of the war in Vietnam were also made.

Godel was very much aware of the White House concern with these issues. Inside DOD he worked closely with Deputy Secretary Gilpatric's office. Gilpatric chaired an interdepartmental task force (the forerunner of Robert Kennedy's Special Group on Counterinsurgency) which reviewed the Vietnam situation for President Kennedy immediately after the Bay of Pigs incident and recommended significant expansion of U.S. assistance to Diem. Whether by his own contact with White House staff or through other DOD senior personnel, one of Godel's ideas was picked up by Rostow and suggested to the President as a possible initiative, namely:[92]

> The sending to Viet-Nam of a research and development and military hardware team which would explore with General McGarr which of the various techniques and gadgets now available or being explored might be relevant and useful in the Viet-Nam operation.

At an NSC meeting on April 29, 1961 the President specifically approved the idea in the following language: "Assist the G.V.N. to establish a Combat Development and Test Center in South Vietnam to develop, with the help of modern technology, new techniques for use against the Viet Cong forces. (Approximately 4 U.S. personnel.)"[93]

The NSC decision was transformed into a formal ARPA assignment from the DDR&E on the basis of a letter to the DDR&E from General Lansdale who was by then an aide to the Secretary. When General Taylor, the President's military adviser, was sent on his crucial mission to Vietnam in the autumn of 1961, Godel and Rathje were part of his team and drafted the "R&D" section of his report.

Godel's success is not surprising -his assessment of the problem in Southeast Asia closely corresponded to the views of the Kennedy leadership. As Sorensen has said, the President quickly realized that he had not only inherited a commitment and a growing conflict but also:[94]

> [A] largely military response to revolution ... a military policy which had left us wholly unprepared to fight -- or even to train others to fight -- a war against local guerrillas. Our military mission had prepared South Vietnam's very sizable army for a Korean-type invasion, training it to move in division or battalion strength by highways instead of jungle trails.

Godel's suggestion to use R&D resources to overcome some of the problems was plausible and the notion of doing the work on location directly for and with local forces had great practical appeal.

Ruina, primarily wrapped up in restructuring DEFENDER, coping with nuclear test detection issues and generally learning about ARPA during his first few months, had little say about AGILE's arrival:[95]

> AGILE was one big embarrassment to me. I never liked it. I didn't want it. Somehow Godel and his cohorts foisted it upon the system. And Harold Brown sort of thought it was important too. I never was an enthusiast for it. I was always afraid it was going to be a collection of gadgets that had no relevance to the world.... It got some support from the top, surprisingly enough. I think Harold Brown ... thought it was all right.* If I had got any support from the top saying it was nonsense, I think we would have stopped it.

* If Brown left this impression, it was probably either transitory or a reflection of White House desires because Godel, Sproull and Herzfeld all recall Brown's attitude as being in a range from decidedly cool to negative.

"Stopping" was not in the cards. AGILE was to grow rapidly to the $30 million per year level.

AGILE Organization and Program Focus. Project AGILE first appears in ARPA's semi-annual report series in April 1962.* Official assignment of the project was made in mid-1961 and work gradually got underway in the latter half of the year. Though, as previously described, AGILE received some support from high levels, the original project mission was modest and the organization described in 1962 gives few hints of the considerable growth which was to occur in succeeding years. In fact, the initial impression given was that this was to be one of ARPA's smaller efforts.

To illustrate, the original project title, "Southeast Asia Combat Development and Test Center Activities (AGILE)," suggests that its scope was limited geographically and to activities with (or related to) specific foreign "centers" which were established in Vietnam and in Thailand. The project description states:[96]

> Project AGILE is a program of research, development, test and evaluation in counterguerrilla warfare in Southeast Asia. It is designed to assist indigenous troops engaged in combat in remote areas by identifying and satisfying their research and development requirements.
>
> The RDT&E work is carried on in joint host nation/U.S. Combat Development and Test Centers (CDTC) in Saigon, Vietnam, and Bangkok, Thailand, and in the United States in those cases where field work is not practicable. The Saigon CDTC is intended to concentrate on short-run measures most likely to contribute to the present conflict. The Bangkok CDTC undertakes long-run projects and work that cannot be accomplished in Vietnam due to unsure security conditions.

The purposes of the project were thus sharply focussed on assisting indigenous troops and there was a clear division of responsibility between the Vietnam and Thailand offices. Unlike the "major" project offices of the Ruina period, there were no organizational sub-elements of AGILE listed in this first statement.

The description of initial AGILE work also indicated modest beginnings. Three projects were described (all in Vietnam, with the Thailand office just opening). The first was an evaluation of a foam plastic, shallow-draft boat capable of carrying eight to nine Vietnamese soldiers in the

* ARPA issued semi-annual or annual reports from 1960 through 1967, when they were discontinued.

Mekong Delta environment. The second was an assessment of the practicality of introducing military dogs to Vietnam in a combat role. The third was a study of the potential use of chemical defoliants to clear roads and border areas and possibly disrupt Viet Cong food sources, culminating in a limited operational test which "yielded generally inconclusive results."

Indicative of Godel's sensitivity to the insurgents' mode of operation, especially the effort they were prepared to devote (in contrast to the governments they were challenging) to influencing the populations within which they wished to operate, ARPA arranged to send an excellent anthropologist, Dr. Gerald C. Hickey, to Vietnam. Operating nominally under RAND Corporation auspices, Hickey spent years in Vietnam, operating almost as a free spirit, adding to his unique understanding of the Vietnamese hill tribes and providing unvarnished advice to Vietnamese and U S. officials alike about hill tribe problems. His hiring represents a prologue to and actually the high point of, later ARPA attempts to promote research on the culture and behaviors of populations subject to the threat of insurgency.

The idea of inviting behavioral scientists, especially anthropologists, sociologists and social psychologists, to undertake research on societies and groups undergoing stress in the inevitably changing world in which they found themselves, was deeply ingrained in the originators of AGILE. The basic attitude was that the people best-equipped by training and inclination to understand and shed light on these problems had been the last to be "invited in" to do so. This proved to be an exceedingly naive outlook, in part because some social scientists preferred to carp and criticize rather than contribute, and in part because they ranked their personal research interests higher. There was sometimes more than a trace of hypocrisy in the notion of doing a study of one's "own" hill tribe in a particular country, yet refusing to undertake any work dealing with the forces of change there and simultaneously criticizing the host nation government, foreign governments and international organizations for doing an inept job of "coping." The subsequent widespread disenchantment with U.S. policy in Vietnam should not be permitted to obscure the fact that long before that entirely valid reaction began to set in, social scientists by and large failed to make their skills available in the search for answers. Hickey was by all odds the exception, not the rule.

The 1962 budget for AGILE was $11.3 million -- about a tenth the DEFENDER budget, a sixth of VELA and half of the materials and propellants projects. The program's beginnings were thus quite unpretentious and imply a rather modest continuing effort, non-threatening to the Services. This was to change considerably, however, by the time of Dr. Sproull's appointment to the ARPA directorship.

The Services never accepted the legitimacy of ARPA's AGILE role and actively fought it much of the time. One of the ironies of this battle is that while Godel had the ability to create the project, obtain White House endorsement and get a Secretarial assignment, he and the Agency were not able to get sufficient backing within the Department to prevent Service interference. The Commander-in-Chief, Pacific (CINCPAC), Admiral H. D. Felt, was a particularly obstreperous foe. "Old line" in the fullest sense of the word, Felt took umbrage at any OSD personnel being located in "his ocean" unless they were under his detailed control. ARPA staff in Washington and in the field devoted countless hours of effort and frustration to dealing with the many bureaucratic obstacles Felt placed in their way, largely in the form of a maze of project approvals involving his representatives in Vietnam, Thailand and his own headquarters. Felt and Godel negotiated a nine page Memo of Understanding in February 1962[97] that set the ground rules, but they always remained matters of contention. ARPA found it very difficult to manage a field empire 12,000 miles away, more often than not harassed rather than helped by the Services, and neither the Secretary nor the DDR&E were prepared to devote time to deal with what appeared to be picayune matters of administration. ARPA staff in the field, who took pride in being part of OSD, came to feel neglected and ultimately "disowned" by the Office of the Secretary.

It became clear that ARPA would not be granted a sufficient number of civil service or military billets to staff the new field units, and even if it had them, it was generally believed that high quality talent would not accept the pay scales. Industry and the not-for-profits argued that they had the flexibility to recruit and attract the sorts of technical people needed. Thus staffing was predicated on having a small cadre of OSD civilians and officers in the field units supplemented by consultants, contractor teams and occasionally personnel from Service R&D commands or laboratories for specific projects. Events were to prove that this rationalization was erroneous. Contractors rarely could deliver high quality personnel and never attracted their very best people. Many of them were marginal or worse, with a heavy sprinkling of "pick-ups" or "walk-ons." The main reasons were an unwillingness to take families to a foreign country for extended periods, fear of losing out on the corporate career ladder in the U.S. (the realistic 'out of sight, out of mind' syndrome), and lack of interest in the subject matter. ARPA was completely unable to overcome this handicap. It posed the challenge of working on new scientific and technological problems, but top rank men did not take the bait. Initially, however, hopes were high.

The AR-15 Experiment. The most successful AGILE project during the Ruina period, and probably the most frequently cited AGILE success over the program's entire history, was the testing of the AR-15 rifle in Vietnam. The project tests, which showed the AR-15 (later renamed the M-16) to be superior to available alternatives, eventually led to the acceptance of the weapon not only in Vietnam but throughout the U.S. Armed Forces. Godel, a critic of Marine Corps and Army resistance to new ideas, "wanted to stick a finger in the Army's eye ... he wanted to stick the M-16 down the Army's throat, successfully."[98] He did.

The requirement Godel created for the AR-15 tests stemmed from "the need for a weapon compatible with the small stature and body configuration of the Vietnamese soldier and responsive to the acute problem of poor visibility and fighting at short range in heavy rainforest and mangrove swamp areas."[99] Shortly after the Combat Development and Test Center was established in Vietnam, this need (expressed in terms of dissatisfaction with then U.S.-supplied weapons, such as the M-1) inspired the ARPA/AGILE staff to review alternatives -- and attention quickly came to be focussed on the industry-developed (Colt-Armalite) AR-15. A preliminary test of ten of these rifles in the late summer of 1961 generated an enthusiastic response and the Chief of the Military Advisory Assistance Group requested additional rifles for further testing. Despite strong opposition within the Army, the request found its way to OSD and ARPA, and ARPA quickly performed a thorough cost-benefit analysis which concluded that further testing was warranted. Subsequently some one thousand AR-15 rifles were sent to Vietnam for further testing (including combat tests), which conclusively established the superiority of the new weapons. Later in 1962 the U.S. Air Force adopted the rifle and Secretary of the Army required additional Army testing (in comparison with the Army's M-14 and the Soviet AK-47). These tests led to limited Army procurement of the AR-15/M-16 in late 1963, and eventually to the fuller adoption of the M-16 in 1966.* In short, the initial ARPA tests pointing toward limited Vietnam applications produced results which ultimately changed the mix of small arms throughout the U.S. Armed Forces completely, and the M-16 came to be regarded as a truly superior weapon.

The history of the period indicates that the development of the M-16 would almost certainly not have come about without the existence of ARPA as an alternative source of funding and a vehicle for objective testing. The Army was completely committed to its own M-14 development program and fought the ARPA test program all along the line. Both the Chairman of the JCS and the CINPAC were strongly opposed. ARPA's role as broker between the "user" in Vietnam and OSD in Washington was critical to building a case for the weapon which could overcome Army resistence.

The Air Force was amused by the Army's embarrassment and, as noted, contributed to it by selecting the Armalite rifle for its new Air Commando forces. Air Force was less amused later when it found ARPA supporting designs for a Counterinsurgency or COIN aircraft. The theory was much

* By this time, however, the Army had modified the rifle, and the modifications created severe difficulties with the weapon in Vietnam before they were corrected.

the same, namely, design for indigenous forces an aircraft that is simple to fly and to maintain, and is configured to satisfy elementary missions and nothing else. Eventually the Air Force got around to designing a plan remarkably similar to the original ARPA-supported concept and North American built it. It could have been forced on them by ARPA's activities or it may simply have been a defensive move, but they did it.

The AR-15 case appears to be one in which strong preexisting Service commitments created resistence to any change to an alternative weapons option -- which, at the time and in retrospect, appears to have been clearly superior. If the AR-15 was superior, however, ARPA had nothing to do with that fact. It spent nothing on rifle development and less than half a million dollars on a test program. In this case ARPA was essentially an alternative mechanism which served higher OSD echelons, interested users and (undoubtedly) the weapons manufacturer in promoting a promising concept that otherwise would have been neglected. AGILE staff quality on the project was apparently high and the AGILE mission, to support the special needs of indigenous forces, gave it the necessary legitimacy to serve this role.

Even Ruina considered the AR-15 an ARPA success story. "They were rather heroic in that," he said, "I was proud of it."[100] It was not science, it was not multi-Service, and it was in an area -- ordnance -- that lay at the very heart of what a Service traditionally handled. In other words, it was not the sort of thing ARPA was supposed to be doing, although it clearly was the sort of thing that somebody in OSD should have been doing. ARPA succeeded via the disguise of "R&D support for indigenous forces." The Agency won this battle, but later lost the war.

Materials Sciences

The Materials Science office during the Ruina years was dominated by the Interdisciplinary Laboratory program, which comprised some $15 million of a $20 million annual budget. The central importance of the IDL programs was not just budgetary, however, but also conceptual. In fact, the program statements of the period read:[101]

> The objective of the material sciences program is to substantially strengthen United States research in this field. The objective is being achieved through the establishment of materials sciences centers at selected universities.

Thus the IDL program was essentially the Materials Sciences program and any other activities undertaken by the office were distinctly secondary.

As a sign of the times, it should be noted that while the materials program was felt to be quite Defense relevant, it was not deemed necessary to even mention military requirements in the above program statement. Underwriting materials research in American universities appears to have been simply taken for granted as a legitimate Defense R&D function, and military needs tended to be left unstated or mentioned merely in passing in contemporary statements on the program. Unlike DEFENDER, VELA and AGILE, which were driven by national defense policy requirements, the impetus behind the IDL program came from the felt need to upgrade the state of the science, with applications to military requirements expected to flow as by-products of the effort.

During the Ruina period the residual $5 million or so in the materials office budget was primarily devoted to two ancillary projects. One was the previously mentioned program of equipment grants to universities other than the twelve selected to become IDL's. Like the IDL program itself the equipment grant program simply provided support to university infrastructure for basic research in materials and was not tied to specific projects addressing military problems. The other program was in "crystal growth." This also was a form of support to the basic research infrastructure, since a major limitation in university solid state research was the unavailability of single crystals of high purity and crystallographic perfection. The crystal growing program was designed to provide a breakthrough in crystal availability and hence to provide timely assistance during a period of vast expansion in solid state research. The early 1960's, incidentally, marked the beginnings of the solid state revolution, when the far-reaching impact of this technology on civilian and military equipment systems was just becoming widely recognized.

Turning to the IDL's, these major university projects finally began to take shape in the Ruina period. Roy Johnson had presided over the generation of the concept and the initial program assignment, and during Betts' year effort was devoted to structuring the program concept, organizing an office and initiating university selection for the first three laboratories. The first two years of the Ruina period (roughly calendar years 1961 and 1962) were largely devoted to the difficult and time-consuming process of selecting nine more university participants, and establishing contracts. That this was an enormous task is illustrated by the fact that in the first round of selection, which resulted in three funded IDL's, 34 universities submitted proposals; in the second round of proposals, resulting in nine funded IDL's, 42 proposals were received.[102] Thus for a total group of twelve ARPA IDL's which would receive approximately $18 million in annual funding, seventy-six proposals were received, the dollar value of the proposals incidentally totalling over $300 million.

Obviously the universities felt that the program was extremely significant, and competition was intense. As Sproull remarked later, "The unsuccessful competitors have not been shy about their unsuccess."[103] It should also be noted, though not further discussed here, that there was significant Congressional interest in the selection process, with efforts made to ensure that constituent universities were given proper attention. In any case, the selection process was highly sensitive and conducted with laborious effort.

The criteria used for IDL selection are of interest in assessing the subsequent history of the program. According to Sproull, who served as head of the Cornell IDL before coming to ARPA in 1963:[104]

> (1) Selection was not a prize for the past performance but was acknowledgement that the selected institution was especially promising as a place to build research, (2) Universities that had already taken a serious commitment toward expanding and generalizing materials research and training competed favorably, (3) Institutions that demonstrated a willingness to experiment, to bestir themselves from the comfortable seat of tradition were favored, (4) Finally, as in any such selection, luck played a large role, since in some cases the transfer of a single leading professor or the happenstance of existing building plans at just the right time could make the deciding difference between close competitors.

In a contemporary paper the following additional criteria were also cited:[105]

> (a) Strong faculty reputation, (b) Established close relationship between teaching and research programs, (c) Sound university management, (d) Demonstrated interdisciplinary efforts, and (e) Past rate of university growth (used as a measure of ability to absorb a major new program).

Out of the rather painful selection process, ARPA emerged with the following twelve IDL contracts: Brown, Chicago, Cornell, Harvard, Illinois, Maryland, MIT, North Carolina, Northwestern, Pennsylvania, Purdue, and Stanford.

The scope of these contracts was set forth in rather broad terms:[106]

> The contractor shall establish an interdisciplinary materials research program and shall furnish the necessary personnel and facilities for the conduct of research in the science of materials with the objective of furthering the understanding of the factors which influence the properties of

> materials and the fundamental relationship which exist between composition and structure and the properties and behavior of materials. To this end, theoretical and experimental studies in such fields as metallurgy, ceramics science, solid-state physics, chemistry, solid-state mechanics, surface phenomena, and polymer sciences shall be conducted, as well as other research investigations which may be mutually agreed upon by the contractor and the Advanced Research Projects Agency.

Again, there was little guidance provided to orient the IDL's to projects of specific military interests. In addition, there appeared to be little effort to encourage specialization among the participating universities, beyond what might evolve naturally from faculty interests.

By the end of the Ruina period, the IDL's had been built and were beginning to operate. It was really not until the Sproull period, and in some cases the Herzfeld period, that the products of the ARPA investment really began to become discernible. These products were to be essentially a large expansion in materials faculty, students, degrees, research staffs, dissertations, and research projects.

Program expenditures in the period before the IDL's were actually operational were devoted largely to construction funds and, particularly, to building up the "forward funding" accounts to which the ARPA program was committed. Providing three years of advanced funding was relatively painless, and perhaps politically feasible, because it was spread over several years when there were no current operational expenses; that is, ARPA did not budget $60 million in any one year -- e.g., $45 million in advance funds and $15 million in current funds -- but rather devoted most of its early allocations to gradually accruing advance funds while the selection process dragged on.

Command and Control Research

Command and Control Research (CCR) was assigned to ARPA in June 1961 and appeared in the ARPA budget for the first time in FY 1962, as a Ruina period initiative. In fact, though memories are obscure on this program assignment and documentation is lacking, it was most likely generated in the latter half of the Betts period. By May 1961, the decision had already been made to use DOD emergency funds to start the project in ARPA and considerable prior discussion was undoubtedly required to bring the issue to this point. The program's origins appear to be quite similar to the toxicology and arms control assignments developed during the Betts period in that DDR&E was faced with a specific management problem and tapped ARPA as a convenient mechanism to resolve the issue.

In the case of Command and Control Research, DDR&E's problem appears to have been the existence of a rather expensive computer (the AN/FSQ 32XD1A) built as a back-up for the SAGE air defense program, which the Air Force had determined was no longer needed and hence was available for other purposes. There was also considerable interest within DDR&E in computer application to war gaming, command systems studies and information processing related to command and control, as well as concern about the continued utilization of the Systems Development Corporation (the major software contractor for the Air Force) which apparently was experiencing some cutbacks in support due to the stage of development of Air Force programs. DDR&E thus had a major piece of computer hardware begging for use, strong interest in computer applications to command and control, and an available contractor asset with appropriate credentials (SDC was a contemporary leader in software development). In the view of an ARPA staff member assigned to the early CCR program:[107]

> [A]pparently there was the decision that there was a hell of an investment here [in the computer] that had great use ... and I think they saw an opportunity to kill two birds with one stone. To get into command and control research at the OSD level, and also help SDC over a hump.

Another ARPA staff member of the period observed simply that the computer was a rather embarrassing "white elephant" and the Air Force had considerable "sunk costs" in SDC's capabilities; hence there was heavy pressure to capitalize on this investment in machines, software and people.[108] Given the lack of an Air Force mission and the absence of any other appropriate operational agency in OSD to handle the program, ARPA was the logical place to go with the problem.

The scope of ARPA's CCR program, as established in Dr. Ruina's first year, was simply to put together this one project. Funded at $5.8 million, including computer shipping, installation and check-out, the description of the program read:[109]

> CCR was assigned to ARPA in June 1961. Its primary purpose is to support research on the conceptual aspects of command and control and to provide a better understanding of organizational, informational, and man-machine relationships.
>
> The shipping and installation of an AN/FSQ-32XD1A computer at the Santa Monica plant has been accomplished. The development of a technical plan to guide and focus the research at the Systems Development Corporation has been completed.
>
> ... Detailed war game scenarios are being completed with a data base covering military, political,

> geographic, and economic information with industrial, transportation and communication overlays. Processing of these scenarios and other simultaneous projects should lead to the first useable research results.

Tasks described for SDC included command and control studies, research on information processing techniques and methods, development of a "command systems laboratory," and maintenance of a general purpose computer facility.

Whereas the other "specific problem" assignments of the 1960-1961 period quickly died on the vine, ARPA's assignment in Command and Control Research evolved into a broad program of advanced research in information processing. By the 1970's its lineal descendants accounted annually for about $30 million of ARPA's $200 million budgets. The assignment therefore, had a major, enduring impact on the character of ARPA for years to come. The changes which led to this development were made quite soon after the program's assignment during the Ruina directorship.

To preface a description of the program's reorientation it should be noted that this assignment had three major advantages, in terms of growth potential, over the other short-lived assignments of the period. First, ODDR&E wanted it. Second, if CCR was a "white elephant" it was at least a bigger elephant than most of the others. The assignments in arms control, reliability, toxicology and weather control, for example, all began with trivial levels of funding. CCR, on the other hand, started with almost a $6 million budget; hence there was flexibility to move in new directions by internal reprogramming. Third, the objective of examining computer applications to command and control issues was a new area with relatively little established Service interest and entailed far less constraint on ARPA's freedom of action. By contrast, STRIVE was assessing specific satellite projects, TORES inherited a joint-Service program, BATCW attempted to interface with weather projects in all three Services, and ARA was directly linked to ISA and ACDA interests. The impression one gains of the CCR assignment, however, was that ODDR&E breathed a sigh of relief when ARPA took the back-up SAGE computer and SDC support problems. The DDR&E then proceeded to delegate continuing program initiatives to ARPA. Thus due to political, budget and programmatic considerations, CCR was subject to fewer constraints than the other transitional assignments.

Ruina scouted around for someone to take over direction of both CCR and a new Behavioral Sciences assignment. He found his man in Dr. J. C. R. Licklider, a highly regarded specialist in psychoacoustics then at Bolt, Beranek and Newman. Licklider had previously been associated with Lincoln Laboratories and the SAGE program. He came to ARPA in October 1962 because he interpreted improvements in command and control to be heavily dependent on fundamental advances in computer technology, and

Licklider was committed to seeking advances in that field, particularly "interactive computing." When he arrived Licklider found himself exceptionally free to develop the program in accordance with this perspective:[110]

> Jack seemed too busy; he was just relieved to get somebody to run the office ... I talked with him periodically [and] he would make suggestions about directions of things, but pretty much let me do what I wanted to do.

Nor was there much direction from DDR&E. Dr. Fubini was occasionally called on for support, but the special assistant specifically in charge of command and control "was absolutely overwhelmed by immediate problems."[111] Dr. Licklider, therefore, began to reorient the office in line with his view of the importance of fundamental advances in interactive computing. This was accomplished, he stated, with "only an act of belief on my part, some faith on Ruina's part, support from Fubini and a few people like that."[112]

The linkage between command and control research and advances in interactive computing was, in Licklider's words, as follows:[113]

> There was the belief in the heads of a number of people -- a small number -- that people could really become very much more effective in their thinking and decision-making, if they had the support of a computer system, good displays and so forth, good data bases, computation at your command. It was kind of an image that we were working toward the realization of.... It really wasn't a command and control research program. It was an interactive computing program. And my belief was, and still is, you can't really do command and control outside the framework of such a thing ... of course, that wasn't believed by people in the command and control field.

But while the need for fundamental advances in interactive computing may not have been seen in the traditional command and control community, it was supported by the ARPA Director:[114]

> I had been exposed to some of the Defense Department's interests in large computers and what they would do. [The] intelligence community had a program that had large computers ... and [I] used to press it for examples [of computer uses] and it came up with the most asinine kinds of things ... [suggested applications were] such obvious baloney that I was turned off by the whole thing.

> And in so many applications it was rather clear that ... the hardware was there but what to do with it clearly was lacking -- what to do with this tremendous power. So people came around and talked about this whole question of the organization and use of computers for other than purely numerical scientific calculations. It impressed me as being something that was important.

What is difficult to convey in a few words is the almost messianic view carried by Licklider of the potential for advances in the use of computers, the way people could relate to computers, and the resultant impact on how people would come to make decisions (in military command and control, as well as many other contexts). In 1962, however, the "tremendous power" of the computer cited by Ruina was just becoming widely recognized and it was also clear that the procedures used in the first computer generations were highly inefficient and subject to enormous improvement. It was notably evident, for example, that "batch processing" procedures, requiring individual users to wait in line at a computer center to have their problems handled individually and sequentially, discouraged many computer uses and was highly inefficient in terms of human and machine time. The technical opportunities to rectify this situation, through time-sharing and interactive computing more broadly conceived, appeared feasible, at least to men with Licklider's vision. The implications of such opportunities for improvement in computer access, combined with continued rapid growth in computer power and program sophistication, appeared enormous. Symbolic, perhaps, is the nickname given to the group of computer specialists that Licklider gathered together under the reoriented program to exchange ideas: he called them the "Intergalactic Network."[115]

With this view of the mission of the CCR program, it is hardly surprising that Licklider's first efforts were devoted to detaching the project from its sole reliance on a surplus Air Force computer and a single industry contractor, and to bringing the most advanced academic thinking into the program:[116]

> Essentially what I did on the command and control thing was to try to figure out where the best academic computer centers were, and then go systematically about trying to get research contracts set up with them, aiming for three or four major ones and then a lot of little ones.

The SDC program itself was used to this end:

> [T]he main thing was to get what I thought was a clear picture of where the best places were ...

> and I did a little amateur sociometry on that, asking lots of people.... In order to make it easy on myself to meet a lot of these people, and also to do this technology transfer into SDC ... we had at least one meeting, and maybe two to three meetings, at SDC, of a fairly big chunk of the computer community. There were maybe twenty people sitting around the table, kind of free wheeling discussions for a long period of time. And that gave me a lot of opportunity to see who was alive and who was interested in doing what.

Having used the SDC contract as a vehicle to seek out the leading edge of the computer community, the history of CCR in the latter half of the Ruina directorship and the central part of Licklider's tenure at ARPA is one of decreasing emphasis on the SDC work and increasing support for academic "centers of excellence," notably MIT and other institutions in the Boston area. The initial $6 million program at SDC declined to about one third that level by Licklider's departure in 1964, while the total program was expanded from $9 million in FY 1963 to $13 million in FY 1964 and $14 million in FY 1965. The MIT program (named MAC, for "Machine Aided-Cognition," "Man And Computer," or "Multiple-Access Computer") alone had grown to a $3 million level. Emphasis had changed from command operational studies, war game scenarios and a "command systems laboratory" to research in time-sharing systems, computer graphics, improved computer languages, and computer networking.

The ARPA program had thus quickly developed from an expedient solution to an embarrassing Departmental problem involving a specific piece of hardware to a far-reaching basic research program in advanced computer technology, in many ways similar and complementary to the materials sciences program. By the beginning of 1964 this change was reflected in renaming the office Information Processing Techniques, a title that continued unchanged into the 1970's.

Behavioral Science

As noted in the preceding section, ARPA received a small assignment in the behavioral sciences in Dr. Ruina's period which was initially administered by Dr. Licklider. The program had a $2 million budget in FY 1963 and planned future growth was then estimated to reach about $3-4 million.

Initiated out of concern that the Department of Defense was giving insufficient attention to behavioral science research beyond rather narrow traditional Service human factors work, the ARPA program was part of a generally increasing interest in this subject matter in the Department. Promoted by a widely circulated report conducted under the auspices of the Smithsonian Institution, a greater role for behavioral science studies in such areas as human performance, persuasion, and motivation, bargaining and negotiation processes, and man-machine interaction was advocated.[117] In the context of a permissive Department of Defense atmosphere vis-a-vis wide-ranging support for basic and applied research, small initiatives in behavioral sciences research began to be undertaken.

Given its lack of bureaucratic rigidity, relationship to ODDR&E, and increasing role in university basic and applied research, it was quite logical for ARPA to provide a home for the behavioral science program. Program plans were developed in 1962 and by 1963 several contracts were underway, e.g., research in "modeling of cognitive processes" at the University of Michigan, research on computer-aided teaching at Harvard and Illinois, and simulation and gaming studies related to the behavior of international systems at Northwestern. These early studies were low key efforts, and many tended to reflect Dr. Licklider's dominant interest in man's interaction with the computer and in means of increasing the computer's flexibility and utility. Extension of the program into other areas and creation of a separate Behavioral Sciences program office occurred after Ruina's departure.

Energy Conversion (LORRAINE)

By mid-1961 ARPA's energy conversion project, far from growing to the $8-10 million level originally foreseen, was projected to continue only as a $5 million effort. (It was also still considered to be a part of the Materials Sciences office.) The program was described modestly as supporting "basic and applied research to complement Service programs."[118] It was "intended to fill in the gaps which may develop in either the basic or applied research programs of the Services." It specified development of "the basic techniques of thermionic converters, fuel cells, thermocouples, and magnetohydrodynamic generators," and of devices based on such techniques, as its current objectives. Accomplishments, as of mid-1961, were said to be modest: "Most of these programs have barely gotten underway and there are as yet no outstanding results to report."

In fact, the energy conversion program appeared to be somewhat adrift in mid-1961, and considerable interest was expressed in orienting it further toward the long-term basic research support role being played by the Materials office. In a review conducted for the ARPA Deputy Director (Dr. Rathjens) in July 1961, an ad hoc committee reached the following conclusion:[119]

> (1) The program is short term rather than long term and considerable effort should be expended particularly in the University Labs toward the long range

> support of research, i.e., three to five years. (2) There seems to be much too little stress on academic activity. (3) It is not sufficient to await receipt of proposals from Universities, but rather they should be visited to initiate projects. (4) Interdepartmental Labs or interdisciplinary Lab type support should be considered as an additional component of this program. It might even be desirable to consider the establishment of special Labs to study particular aspects of this scientific area, for example magnetohydrodynamics. (5) Even with knowledge of what other agencies are doing it is believed that the program is really too small to have a major impact on progress in energy conversion and it should be at least doubled.

The last point is critical, namely, that the program had come to be regarded as falling well below the funding threshhold necessary to make progress.

Even given the favorable orientation of ARPA's leadership toward basic research support, however, it was determined sometime in this period that energy conversion did not have the priority to merit a major increase in funding (or that such a funding increase could not be absorbed effectively). Consequently, a pivotal decision was made to reorient the project toward a narrower focus and to begin to concentrate on transferrable items.* The program was thus reoriented in 1961 to:[120]

> [To] prepare for "spin off" of a portion of the program. This in turn has necessitated a greater emphasis on device development and proof of principle testing than originally intended in order to arrive at a logical end point or to provide guidance and justification for continued support by the Service agents concerned.

By April 1962 the project was primarily concerned with two "transferrable" projects:[121]

> a. Establishment of the feasibility of a moderate temperature fuel cell capable of operating on air and a common liquid fuel.

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* This was one of two important decisions made during the Ruina period against expanding into a major basic research program in a new field. The second decision concerned support for university programs in electronics, in which case competition with the existing Joint Services program undercut arguments for ARPA involvement.

b. Demonstration of non-equilibrium magnetohydrodynamic generator operation under conditions compatible with reactor technology, and development of an open cycle rocket-powered 20 megawatt MHD generator.

Thus, despite a generally favorable ARPA disposition to longer term basic research, the Ruina period's equally strong emphasis on supporting programs of major potential impact and its acceptance of the value of project transfer seem to have ruled in this instance. The groundwork was laid for termination of this modest continuation of the early space assignments. Like TORES and many of the other assignments of the Betts period, Project LORRAINE was destined to live only a short life.

Atmospheric Processes and Cloud Physics

Project BATON, an assignment in "atmospheric processes and cloud physics," was formally added to the ARPA portfolio on May 24, 1961. While assigned shortly after Dr. Ruina's arrival, it appears actually to have been another product of the efforts to rebuild an ARPA mission during the Betts period. BATON, like a number of other post-space assignments, was generated within ARPA. It was principally the child of ARPA staff member T. W. Brundage, who felt that while each of the Services was doing some research related to climate control, none of them were putting sufficient money into their programs. Taking a leaf from the DEFENDER book, he also believed that basic phenomena such as cloud physics needed greater study before one could develop military applications taking advantage of such phenomena.[122]

During the first year of the program ARPA focussed on two questions: the role of electrification in cloud life cycles and the dynamics of convective and stratus clouds. An airborne measurements program coordinating the efforts of three Service laboratories was established. The budget for this effort was $1 million and a $2 million follow-on effort was proposed for the following year (FY 1963).

This modest climate research program lasted only one year. By the spring of 1962, the Bureau of the Budget had reviewed government weather control projects and found fourteen federal agencies involved. On the basis of this finding, and its own concern over duplication of research efforts, the House Appropriations Committee recommended deletion of the ARPA program in its FY 1963 report:[123]

> The Committee recommends a reduction of $2,000,000, the amount requested, for research in weather control by the Advanced Research Projects Agency. On April 3, 1962, the Director of the Bureau of the Budget submitted a survey of Federal meteorological activities

> which states that there are fourteen agencies involving nine departments and independent agencies conducting research and development programs in meteorology. The same report indicates that broad and comprehensive programs in the study of meteorology are being conducted by the three military services. The Appropriations Committee has, in recent years, objected to the wide dispersal of this activity throughout the Departments of the Government. The Committee believes that having the Advanced Research Projects Agency conducting a separate weather program is not conducive to a coordinated effort in this field and, therefore recommends that the $2,000,000 for this program be deleted from the bill.

ARPA appealed this decision to Dr. Brown, arguing that ARPA served as a coordinating mechanism rather than duplicating Service programs, and that civilian agencies would not provide an adequate level of funding. The DDR&E, however, was unconvinced, or at least was not sufficiently convinced to fight the Congress and the BOB over this small program. Consequently, the program was phased out in 1962, having supported some basic cloud physics research, developed some measurement approaches and instrumentation concepts, and planned some experimental cloud seeding programs.

BATON was thus a modest effort, approved as such by DDR&E and quickly abandoned when conflict arose. The issues of research duplication and military relevance were central to the program's early termination. This event illustrates that Dr. Ruina's ARPA did not have free rein to roam across the frontiers of basic and applied research. Like the initiative in energy research, this program proved to be a false start.

Interestingly, ARPA again picked up the thread of climate research in the early 1970's, this time in conjunction with a greatly expanded charter in computer technology.

The TORES Transfer

TORES, the program addressed to the toxicological problems of military propellants and chemicals, was outlined above in Chapter IV. This assignment gave ARPA a rather carefully defined and circumscribed monitoring role over what had been a long-standing joint-Service effort, and responsibility for a modest level of "add-on" funding. ARPA participation solved an immediate fiscal problem and seemed to reflect a DDR&E view that the post-space ARPA was a useful convenience for handling multi-service R&D programs, without any additional criteria that ARPA problems should be of critical importance, exotic or high risk.

Within about six months of Dr. Ruina's arrival as ARPA Director, however, and only about eight months after the formal assignment, ARPA was striving hard to terminate its role in toxicology. The TORES transfer debate reflects Ruina's image of the proper ARPA role and his efforts to return ARPA to a focus on problems of national importance.

The proposal to transfer TORES was generated by ARPA in a memorandum to DDR&E dated July 27, 1961. This memorandum could not be located, but by subsequent reference apparently claimed that ARPA had lost personnel qualified to monitor the program and possibly also (a point made later, in any case) that the program's stress on physical testing of chemicals did not fit into the thrust of other ARPA activities.[124] Consequently ARPA recommended that the Army be given control of the project and cooperative arrangements with the other Services be worked out under DDR&E (but not ARPA) supervision.

This recommendation drew a reply from the Deputy DDR&E (Dr. Eugene Fubini) which argued that ARPA should reconsider its position. It gave the following rationale for a continued ARPA role:[125]

> This program has grown in breadth and scope and in importance to many aspects of Defense weapon systems since its inception and merger beginning in 1949. The complexities of modern systems employing materials potentially hazardous to our own personnel, and the operational and environmental health hazards unique to the individual Military Departments dictate the need for a dynamic program designed to supply current toxicological information to the Departments. Early operation of the program has shown clearly that without strong central management and consistent funding, economy in the use of personnel and facilities was not achieved, and the overall program suffered from parochial interests.

Dr. Ruina disagreed and reiterated his "strong preference" to transfer the project. His reasons were as follows:[126]

(1) the immediate fiscal crisis faced by the project had been resolved, and ARPA would transfer adequate funds to cover the work until the Army could work it into its regular R&D budget.

(2) the function of "central management" was by itself a DDR&E function and not necessarily an ARPA function; "The point is that I believe that, to the extent this project requires 'central management' this is not more than you would give it in the general course of carrying out your responsibilities."

(3) furthermore, an important ARPA function is to quickly solve critical problems and then transfer responsibilities; "Dr. Brown and I agree that projects assigned to ARPA should not stay here forever and that as the ARPA impact becomes marginal, or less necessary, the projects should move on out. I do not believe that ARPA can, on balance with its other projects, make a sufficiently distinct additional contribution to hold it here any longer."

(4) finally, ARPA should be reserved for more critical problems; "... your efforts can forestall Service conflicts and ... this is not sufficient justification to leave this effort here.... ARPA management should be reserved for more dire problem areas."

Dr. Ruina's position carried the day, and in early October 1961, Dr. Brown advised the Army that it was to take over the core program in toxicology.[127] Thus a decision to transfer the program took place less than a year after its formal assignment.

The instructive aspect of this small case study is that Dr. Ruina strongly expresses two major elements of the ARPA tradition in arguing for termination of ARPA responsibilities: (1) that ARPA should be used primarily for critical R&D problems or "dire needs," and (2) that ARPA must emphasize the timely transfer of projects to the Services. This view is very much in line with the perspectives of ARPA directors of the late 1960's and early 1970's (Rechtin and Lukasik), despite the fact that Dr. Ruina would have considerable differences with them on R&D priorities and despite the fact that he is often associated with moving ARPA toward longer-term basic research programs with less potential for transfer to the military departments. There is, however, a thread of continuity reaching from the Johnson "space" period -- out of which the "national importance" and "transfer" rationales derived -- through Ruina and to the latter-day directors of the Agency.

RUINA'S DEPARTURE

Dr. Ruina left ARPA in September 1963, having served as ARPA Director some 31 months -- a term roughly coincident with the Kennedy years. Unlike his own case, the recruitment of Ruina's successor (Dr. R. L. Sproull) was undertaken well in advance of the actual change of leadership. Ruina participated in the recruitment process and there was a period of months over which the transition in leadership took place. Ruina's departure was, like General Betts', triggered by his career plans -- on this occasion, Ruina's desire to return to the university environment. He first served as President of IDA before moving on to MIT. He announced his impending departure as early as the spring of 1963 in Congressional testimony.[128]

In retrospect, the Ruina period appears to have been the last of the major formative stages in ARPA's history. The Johnson directorship had established most of the "fundamentals" of ARPA -- its status as an advanced high-risk agency, the commitment to remain small, reliance on Service contracting, the principle of not having Agency laboratories, and others. The Betts period's contribution was primarily organizational, namely, the solidification of the DDR&E as ARPA's primary point of reference, the creation of program-oriented offices and the shift to more normal civil service staffing. The Ruina era's legacy was particularly important with regard to the ARPA style. It set the precedent of a civilian scientist-Director and was characterized by delegation of considerable independence to the technical offices, recruitment of strong technical office directors, minimization of bureaucratic functions and limitation of central program management controls, and stress on quality of staff and contractors. The Johnson and Betts periods certainly had profound effects on the future ARPA, but it is the ARPA "life-style" derived from the Ruina period and strongly sustained by Sproull and Herzfeld, which has generated the greatest continuing debate. The issues of research relevance versus research quality and independence, and flexibility versus accountability, for example, particularly relate back to the ARPA style deliberately set in the Ruina years.

The Ruina period underwrote several major new initiatives and gave additional impetus to areas of work established earlier, many of which were to achieve substantial impact under Sproull and subsequent Directors. Alongside these developments were a number of false starts and perhaps questionable commitments. The Ruina ARPA was hence highly dynamic and regained much of the aggressive character that had been lost with Roy Johnson's demise. Dr. Ruina describes the tone of his directorship well in saying:[129]

> I think I had a little bit of the spirit of many of the people in government at that time ... which was that nothing was ever done right before. 'This is the first time that the government is going to be run right since Washington....' The arrogance of the new, young crowd.

In focussing on substantive initiatives rather than administrative form, Ruina left ARPA with an image of a free-wheeling, technically competent but exceptionally loosely-managed organization.

Ruina held his position far longer than his two predecessors. He left a legacy of sound programs and good relations with the DDR&E and the science community; however, he had done little planning for the future and made no effort to establish a group or system for that purpose. Presumably the DDR&E, as the legal source of assignments, would do that. He always considered himself a transient, a "short tour" Director, although he stayed longer than most. Roy Johnson's attempt at planning a comprehensive space program for the future was killed by ARPA's abrupt removal from that field. Betts used his year to worry about keeping the Agency together; long-range planning would have been a luxury. Ruina simply left a void.

Of particular value to ARPA, Ruina had arrested growth of ARPA's negative image among PSAC members and the White House staff; however, there really was no strong institutional connection, no PSAC-ARPA relationship. PSAC was very important to Ruina, personally. He attests that its "values and ways of thinking" greatly influenced him,[130] and he often reflected those values within ARPA, but that was as far as it went.

There was no return to the Roy Johnson days of direct and regular communication between ARPA's Director and the Secretary and Deputy Secretary. According to Ruina, they were only interested in major issues like BMD and nuclear test detection:[131]

> Only in the issues; not in what ARPA has done, but in my involvement in these other issues. And on the substance -- [e.g.] 'nuclear test detection, Where do we stand? What can we do?' [But] not on the question, 'what can the program do?'

Ruina made it clear that the Secretary did not look to him in his capacity as Director of ARPA, but rather as an individual associated with York and Brown in dealing with missile defense and test detection issues. As with the White House, then, the relationship was far more personal than institutional.

Ruina also helped to patch up relations between ARPA staff and ODDR&E staff, but his relations with York and Brown were always better than staff-to-staff relations. ARPA resented even the suggestion of serious line item review of the ARPA program by ODDR&E and felt that the latter had tried since the Betts days to pick on ARPA's small, visible program because of an initial ODDR&E inability to cope with the massive and somewhat impenetrable Service RDT&E bureaucracies it was supposed to monitor. At the least, of course, the ARPA staff wanted to preserve its traditional independence. On the other hand, Ruina says that ODDR&E staff did not find ARPA very useful to them, as opposed to IDA personnel. The hostilities were never very serious and certainly lacked the ferocity of many ARPA-Service and ODDR&E-Service disputes; nevertheless when Sproull took over ARPA he recalled that "Jack and Harold had both told me about the uneasiness, the kind of uneasy truce between DDR&E staff and the ARPA staff."[132]

Most important, ARPA had regained its self-respect. It was no longer under threat of abolition. DEFENDER, VELA and the Materials Sciences programs were viewed as important and high quality, and AGILE was grappling with a problem of immense concern to the White House in a fashion that seemed responsive to White House needs, at least as long as President Kennedy was alive. The Agency's spirit was on the upbeat. As Ruina saw it: "In those days ARPA was for fun, not to make a living."[133]

CHAPTER V: FOOTNOTES

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5. Discussion with W. W. Bolton, Jr., February 5, 1975.
6. Discussion with Dr. J. P. Ruina, June 26, 1975.
7. Discussion with Dr. R. L. Sproull, May 29, 1975.
8. House Subcommittee on Appropriations, DOD Appropriations for 1962, Hearings, 87th Cong., 1st Sess., 77.
9. Discussion with Dr. J. P. Ruina, May 9, 1975.
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13. Discussion with W. H. Godel, June 18, 1975.
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40. Discussion with Dr. R. Holbrook, July 10, 1975.

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43. Discussion with Dr. B. Alexander, July 8, 1975.

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CONTINUITY AND CONSOLIDATION

THE SPROULL YEARS: 1963-1965

The Setting - 1963

Compared to most other transitions in ARPA leadership, the arrival of Dr. Robert L. Sproull as Director was decidedly tranquil. The hallmark of both the transition and Sproull's tenure was continuity in ARPA's immediate operational environment and in the concerns of the Defense Department as a whole.

Since national elections were not involved, McNamara obviously remained as Secretary and Brown as DDR&E. There was little change in the ARPA staff. Charles Herzfeld, who had been appointed Acting Deputy Director under Ruina, was confirmed in that post by Sproull, and by agreement he remained especially involved with the DEFENDER program, thereby providing continuity in the program area that accounted for about 50 per cent of the ARPA budget. W. H. Godel was still de facto leader of AGILE, while heading the policy and planning office and holding the position of Deputy Director of ARPA for Program Management. The expanding information processing program remained under the direction of J.C.R. Licklider. New directors were brought to the VELA and Materials offices, but in terms of program content they were beginning to enjoy the fruits of earlier investments, e.g., the successful launching of the first VELA satellites and the actual operation of the new interdisciplinary laboratories. In fact, across the board ARPA appeared to be in a stage of reaping the harvest of earlier plantings -- PRESS in operation, TRADEX complete, AMRAD operational, ARECIBO about to become operational, Project MAC underway, the AGILE field units in place, etc. There had been no important new program assignments since 1961. ARPA was free to concentrate on those that it had in hand.*

The broader Defense environment in 1963 is also one marked by increased stability and a feeling of accomplishment. The 1962 Cuban crisis had been successfully resolved and the Indian-China border conflict was

* A minor exception to this generalization was assignment of Project STAR, an effort to provide greater protection to Presidents against assassination. It was initiated after the Kennedy event and BOB provided all the funds direct to ARPA. Most of the work involved automobiles, lecturn design, materials, and strategy. According to Sproull, ARPA was selected primarily because it could get the funds out quickly and without publicity. At the time there was great fear that if President Johnson heard about the project, he would cancel it, given his strong feelings about being accessible to the people.

satisfactorily contained from the standpoint of U.S. interests. The NIKE-ZEUS controversy was ended with the decision not to deploy it. NIKE-X became the agreed candidate BMD system for the future, subject to further examination prior to any deployment decision. Arms race concerns were moderated by the conclusion of the Limited Test Ban Treaty at mid-year.

In Vietnam, the U.S. presence remained controlled. The overthrow of Diem at the end of the year was widely regarded as a positive development and the Tonkin Gulf incident which triggered massive U.S. intervention was still a year away. The traumatic Kennedy assassination occurred, of course, at the end of the year, but the Johnson Administration maintained considerable continuity with Kennedy policies well into 1964. The Defense budget stabilized at just under $50 billion, about $8 billion larger than the late Eisenhower years. In space, NASA began to show considerable success and feelings of inferiority vis-a-vis the Soviet effort declined. While disturbing Defense issues continued to arise (such as the vigorously disputed TFX controversy), 1963 appeared to be perhaps the high point of confidence and accomplishment on national security issues since the 1957 Sputnik launching.

The Sproull Appointment

Dr. Robert L. Sproull, who officially became ARPA Director in September, 1963, was the second consecutive ARPA Director to come out of an academic environment. Although Sproull had no previous experience in government he was quite familiar with military research. He had received a doctorate in experimental physics from Cornell in 1943 and during the war worked on microwave radar at Princeton, RCA and the Radiation Laboratory. Returning to the Cornell faculty in 1946, Sproull became engaged in what was to become the field of solid state physics and was part of a group that received one of the first Office of Naval Research contracts. He remained at Cornell until tapped for the ARPA job. At that time he was also Director of Cornell's Interdisciplinary Materials Science Laboratory and hence became the first ARPA Director to have been previously associated with an ARPA-sponsored program. Sproull was a strong supporter of the IDL concept and frequently spoke in favor of this concept among his university peers.

The history of Dr. Sproull's appointment to the ARPA directorship is illustrative of the relatively good reputation the Agency enjoyed with the science community in 1963.[1] In the fall of 1962 Sproull had virtually decided to leave Cornell for a senior post at Wesleyan. The incoming President of Cornell, James Perkins, sought to retain Sproull's long-term connection with the university by attempting to interest him in a shorter term government position which would both provide him with a change and leave open the possibility of a return to Cornell. To do this Perkins encouraged Dr. Jerome Wiesner, the President's Science

Advisor, and (directly or through Wiesner) Harold Brown to consider Sproull for a Federal government post. Sproull was already acquainted with Wiesner through the Materials Advisory Board of the National Academy of Sciences and some other contacts. Eventually Wiesner and Brown were, as Sproull puts it, "twisting my arm in a very agreeable way, saying, would I do one of two things: become Director of ARPA or Deputy Director of the National Science Foundation?"[2] Sproull considered both positions, found the ARPA possibility "just fantastically more interesting" and accepted it. Ruina also had a lot to do with Sproull's decision:[3]

> The thing that Jack really did contribute was a sense of excitement, of being able to, as he put it, 'sign the checks;' being able to start a program, to get the money out, to find something interesting and do it by the close of business that same day. He admitted they didn't do that very often, but the whole spirit of the place was such that you did do that sort of thing.

Both Ruina and Brown confirmed "the free-wheeling nature of ARPA. The fact that it was different from any of the other agencies."[4] Thus the ARPA/DOD environment and relations with the universities were such that a top flight academic scientist (Sproull later became Vice President of Cornell and now is President of the University of Rochester) would be recruited for the ARPA position by the highest ranks of the science community and would accept that job in preference to a highly prestigious civilian science post. By the late 1960's academic disenchantment with Defense policy and the Vietnam war would be so great that such a career choice would be extremely unlikely.

The ARPA Style

The ARPA of 1963 was clearly at the height of what might be called its "academic period." Sproull was both the first and the last of the ARPA Directors to come directly to ARPA from a university environment, a fact which clearly reinforced the orientation of the Ruina period. As one of Ruina's contemporaries in ARPA judged, Dr. Ruina believed that "the ARPA role was basic research, if it was to be truly advanced." [5] We previously noted Ruina's belief that it was more important to do "interesting things" well than to be relevant. Sproull was as insistent as Ruina in demanding quality research, but also gave great stress to applied research of clear relevance to military concerns, notably measurements and analyses in such areas as reentry physics and seismic signal detection, work that was in a sense fundamental, but very directly tied to specific defense problems.

ARPA's shift of emphasis toward basic research and measurements reflects not only the personal interests and backgrounds of Ruina and Sproull, but also a considerable change in perspective as to technological opportunities and the prospects for revolutionizing military weapons systems. Whereas the potential for dramatic breakthroughs in weaponry was given real credence in the first three years of ARPA's existence, such breakthroughs were beginning to be viewed skeptically by the time Ruina took office and appeared much less realistic by the time Sproull arrived in 1963. As York has said:[6]

> Virtually all the new programs that came into being in the burst of inventive activity inspired by Sputnik and the "missile gap" all came to a dead end sooner or later. Nor did they produce any really important "technological fallout" (a term invented to justify expenditures on programs which cannot be justified as ends in themselves). To put it simply, large amounts of money and human effort were wasted in a wild pursuit of the exotic.

ARPA's cancellation of work on exotic BMD systems concepts in the 1961-1963 period was symptomatic of these changes. By 1963, the Agency appeared to be somewhat less receptive to "far out" unsolicited proposals (such as those that had led to the initiation of laser and charged particle beam research for BMD applications) and was not inclined to undertake wide-ranging "brain-storming" projects to elicit exotic concepts (such as the earlier GLIPAR project).

Dr. Brown's testimony before the House Appropriations Committee on May 6, 1963 (during the period of Sproull's recruitment) is illustrative of this changed perspective:[7]

> Dr. Brown: I think the technological revolution which has taken place in the past 15 years is not over, Mr. Chairman. However, do not think that that necessarily means we can expect every two years or even every five years a revolutionary change in the sense of altering strategic balance.
>
> For one thing, the combination of ballistic missiles and hydrogen warheads made a very big single change, and then there have been lots of subsidiary things. In a real way the nuclear submarine is a subsidiary change to that, because POLARIS is the most important kind of nuclear submarine.

Mr. Mahon: Do you foresee anything as dramatic in the next 18 years as we have had in the last 18 years in the field of weaponry?

Dr. Brown: Probably not.

Although we do not know how explicit York was in stating his view at the time, he has since said that:[8]

> [D]uring the early sixties [there] was a genuine scarcity of new, good technical ideas. Even those few that were generated then did not seem to be relevant to the strategic or political problems at hand or anticipated. Hindsight confirms that, in the strategic weapons area at least, that view was correct.

With the DDR&E's assuming a scarcity of good technical ideas, small wonder that neither York nor Brown was particularly expansive about ARPA's role. Ruina and Sproull and their staffs certainly did not believe that important scientific and technological advances were seriously limited, but they clearly were not anticipating immediate, revolutionary breakthroughs. Indeed it remained for Rechtin, ARPA's Director from 1967 to 1970, to declare a genuine shortage of good ideas to work on.

In addressing occasional "Why ARPA?" questions, Dr. Sproull gave relatively little emphasis to ARPA's potential for revolutionary impact on national defense. He preferred to stress responsiveness to the Secretary and DDR&E and ARPA's ability to support research of scientific merit on a long-term basis. To cite Dr. Sproull's FY 1965 testimony before the House Appropriations Committee:[9]

Mr. Mahon: Would it be desirable to abolish ARPA as such and consolidate this work otherwise?

Dr. Sproull: ARPA could be abolished and its tasks distributed among the services and perhaps some of them taken up in other parts of the Federal Government outside the Defense Department.

I believe, and I believe Dr. Brown feels, and I think the Secretary feels that ... having a small instrument, if you will, like ARPA close to the Office of the Secretary of Defense, operating out of

> the Office of the Director of Defense Research and Engineering, enables the Department of Defense to do things more rapidly and more responsively than they could be done through the Services.
>
> ... I would say that in general... ARPA has two advantages. It can get a very quick response as requirements come up, and, secondly, it can have a more scientific involvement, a more long-range point of view, than the services can very appropriately take. (Underline added.)

Though there were storm clouds on the horizon, ARPA was probably more solidly "established" during Dr. Sproull's two-year directorship than in any prior or subsequent period. The Agency was, in Sproull's words, "a terribly strong office" technically and had a reputation for a substantive scientific orientation that was superior to such central science-supporting agencies as the National Science Foundation and the Office of Naval Research: "They never had the spirit that ARPA had in the spring of 1963."[10] Beyond ARPA's respectability in the scientific community, Sproull enjoyed a good relations with Dr. Brown throughout his tenure, which served to protect the Agency from squabbles at the DDR&E staff level.

To his staff Sproull seemed to even more deferential to the DDR&E than Ruina had been, in the sense of not starting anything without the DDR&E's approval. On the other hand, Sproull was aware of ARPA's vulnerabilities and prized Brown's support. ODDR&E staff, including the Deputies, often did challenge ARPA, frequently in the role of referee in alleged disputes between ARPA and the Services. That is, DDR&E staff would hear complaints about ARPA from the Services and raise them with Brown. Sproull made a fetish of religiously attending Brown's twice weekly staff meetings in order to deal with such matters and establish ARPA's influence. He remarked that "over and over again I got into problems because I didn't know enough, in detail, about what our ARPA people were doing when it interfaced with DDR&E, or with some program in the Services that DDR&E had as an issue, in front of them."[11] This is one of the prices paid for having a small organization engaged in a broad array of project activities, based on the principle of managing via highly independent office directors. Brown, however, apparently recognized that ARPA programs were readily visible, and hence "easy pickings," and normally protected them from indiscriminate sniping. Sproull described his relationship with the DDR&E as follows:[12]

> Harold said to me 'I control the people in ARPA and therefore I don't have to control the programs' ... that was the key statement that

> Harold made to me, and I think I must have said something to the effect that 'I'm sure that I'll need to use that statement from time to time.' A couple of times when Dan Fink's people were really trying to run Sam Rabinowitz's shop [ARPA EMD Office] I would have to go into Harold's office with Dan and Sam and let Harold say that in the presence of all those people. And he did.... So, that to me was a very important statement and one that we needed over and over again, and kind of set the tone of the relations between ARPA and DDR&E. That was one of the things that gave strength to the Agency.

On the other hand Brown, like York, had no expansive ideas regarding the use of ARPA and suggested no major new assignments. Perhaps this reflected his pessimistic estimate of the liklihood of "breakthroughs." In any event ARPA "was stable as far as Harold was concerned." He was comfortable with DEFENDER and VELA, and uneasy about AGILE. Beyond that, "Harold wasn't trying to turn any sharp corners with ARPA." Sproull himself shared this view:[13]

> I didn't have any concept that I would have to change the Agency.... I didn't have any messianic approach.... It seemed to me that the thing was very strong, that I would have a terrible time just keeping up with it....

Relations with the Secretary, as in the Ruina period, were controlled by the DDR&E. Sproull recalls being in the Secretary's office two or three times, accompanying Brown. As Sproull puts it: "McNamara had tremendous respect for Harold Brown and Harold was taking care of ARPA, so why should the Secretary [see me]."[14] There was a bit more direct contact with the Deputy Secretary, Cyrus Vance, most of it in the context of disputes over Project AGILE activities. If ARPA had a vulnerability, it was AGILE specifically and a lack of intimacy between ARPA's programs and related Service efforts generally.

Since Dr. Sproull felt no need to change the agency, it is hardly surprising that his interests approximated Dr. Ruina's, namely, according highest priority to the DEFENDER and VELA programs. Regarding DEFENDER, Sproull placed great emphasis on the program's implications for both offensive and defensive strategic technology:[15]

> When I decided to go there [to ARPA] the one thing that I was most interested in was doing everything I could on the famous cliche 'the light at the end of the tunnel,' on the strategic deter-

> rent, through Project DEFENDER -- that was the thing that really turned me on most.

As with Dr. Ruina, Sproull remembers that "... the VELA business was [along with DEFENDER] the thing ... more than any other thing that turned me on."[16] Even more strongly than Ruina, Sproull felt that the VELA work had significant influence on the test ban negotiations, ultimately in permitting a test ban to be signed. His main point is that the capability represented by VELA gave needed assurance to skeptics that nuclear test detection safeguards would be vigorously developed after a treaty had been negotiated:[17]

> ...The Joint Chiefs, and through them, the Congress was relying not so much on any particular piece of knowledge that ARPA had produced -- although there was a lot of that in those hearings that spring -- but on the fact that here was an agency that was believable and one you could trust. High level technically and well-funded; light footed, unbureaucratic, going at these [things]. And here's what they're doing, here's what they're doing, here's what they're doing. And we can rely on that. It was that kind of philosophy.

Summarizing Sproull's views on this subject:

> In my mind there's no doubt, there are three reasons for the partial test ban. One that Mr. Kennedy wanted it. One that the Soviet Union wanted it. And one that ARPA made it possible for the Senate to ratify it. And all three of those were required.

Herzfeld also believes that the DEFENDER program was a factor in gaining acquiescence.[18] The JCS and others had raised some very technical questions about nuclear effects, that is, the ability of nuclear explosions to "blackout" instruments intended to monitor what was occuring. The argument was made that much more background data were needed. On the basis of DEFENDER studies, it was possible to explain what the uncertainties were and to show that they were no greater in effect than a number of other non-scientific uncertainties where were also present and could not be "fixed," i.e., it was irrelevant to worry about the alleged technical deficiencies. According to Herzfeld, he, Harold Brown, Paul Nitze, and the late John McNaughton were able to work this out: "We showed that it was possible to build a reasonable system with these uncertainties, given the non-technical uncertainties that were inherent in the Limited Test Ban Treaty situation."[19]

Keenly interested in the two largest ARPA programs and relatively satisfied with most of the rest of the effort (excepting an urge to change Materials Sciences and continuing doubts about AGILE), Sproull did relatively little to modify the basic directions of ARPA activities. He did tend to pay more attention than his predecessor to the "smaller" ARPA programs, in part because they were becoming more interesting and in part perhaps because he was called upon less often than Ruina to engage in DDR&E activities external to ARPA's concerns.

Sproull had a flair for making every office director feel important. His genuine interest in quality work and high level of professionalism and personal commitment rubbed off on Agency personnel. In particular Sproull demonstrated real concern in the Agency as an institution, and in its people, i.e., it was obvious that he identified with it. Morale was high.

In summary, the Sproull ARPA was very much an extension of the Ruina period in terms of priorities, spirit and philosophy. As noted earlier and as will be seen in the following section on ARPA's programs in that period, it was also a time of considerable achievement in the established work effort.

Internal Management

Sproull was somewhat more interested in and diligent about management than Ruina. He relied heavily on Donald K. Hess, Director of Program Management, for advice and permitted a greater degree of influence for management-oriented people. While not going so far as to reinstitute a Program Council, Sproull and his Deputy conducted serious thrice-yearly review sessions with the office directors and took administrative issues to heart. At the same time, Sproull was a dedicated believer in the "barony" system of management, i.e., to attract the best people one has and to offer them latitude for freedom of action:[20]

> I guess I got the view very early that the real problem would be to make sure that they got the right people in ARPA. And in a way, as a kind of extrapolation or extension of the Harold Brown principle, that ... I'd try to control the people and then try to given them as much maneuvering room as possible on the programs. And that's what I spent most of my time in ARPA on, hiring and also firing. I remember that my principle was that I wanted to give walking papers to at least two professional people a year. And I think we did that. The idea being not to be cruel in discharging people, but only that there were certainly going to be some people who were not carrying their load as much as they should at the

> bottom of the Agency, and the message might get across a little bit farther up, if you managed to find jobs [outside of ARPA] for people farthest down.

Sproull was a strong supporter of the Information Center concept that became something of a fad in the 1960s. From the Ruina period on, ARPA included rather generous funding in many of its programs, e.g., DEFENDER, VELA, AGILE, and Solid Propellants, for specialized information centers and data exchange procedures. The fear was that masses of information would overwhelm specialists in a field and/or the existence of classified information would not be known to those who should have it, especially government contractors. Looking back on it, Ruina thinks that this concern was "terribly exaggerated."[21] Sproull gradually became a skeptic too: "The way some of the information centers are going, the world is going to be flooded with unevaluated, uncritical, inconclusive, self-contradictory 'information' or misinformation...."[22] The consensus today seems to be that most of the centers were a luxury. Passed on from one ARPA director to another, however, they managed to survive for years.

Sproull was also especially concerned over the potential distorting effects of indiscriminate Federal funding of university R&D. He devoted a great deal of attention to clarifying ARPA's position on university sponsorship, and he resisted university efforts to build up large R&D staffs solely funded by ARPA and other federal sources, recognizing that sooner or later the federal tap would be turned off, with serious consequences for the schools. He insisted that ARPA not be vulnerable to future charges of irresponsible expansion of university programs.

Clearly ARPA was maturing in status, program, management, and institutional outlook.

PROGRAMS IN THE SPROULL PERIOD

Program Status - 1963

Sproull's ARPA may be viewed as an extension of the Ruina period in terms of priorities and Agency philosophy and it was characterized by major substantive developments within the established program offices. Because of the extent to which programs seemed to mature in the Sproull era, a review of the status of these efforts at the time he took office in mid-1963 is useful in providing perspective.

By 1963 the DEFENDER program had been rather thoroughly shaken down under the direction of Dr. C. M. Herzfeld. The "far out" systems concepts which received so much early attention essentially had been

[redacted]

abandoned: BAMBI was clearly dead, HELMET was rejected as a serious candidate in the foreseeable future, and ARPAT was continued on the basis of anticipated "technology advancement" benefits (especially the AMRAD radar) rather than its value as a systems concept. Sproull seemed to share the "systems" pessimism of his predecessor. ARPAT, he said, was "not so hot, to say the least; it never led to anything."[23] The three exotic advanced BMD technologies -- charged particle beams, lasers and directional nuclear weapons -- were also being supported largely because of a desire to more thoroughly explore the technologies involved rather than because of any real optimism that an affordable weapons system would suddenly emerge. In fact, all appeared to be regarded quite pessimistically in 1963: beam instability problems appeared likely to be insurmountable in the charged particle field, power limitations in solid state lasers had become quite obvious, and overwhelming obstacles also appeared in the way of developing directional nuclear blasts of value for BMD purposes. Indeed Sproull once tried to kill the charged particle beam project during his tenure, but could not overcome the scientific community's belief in Christofilos. ARPA wound up supporting him as "a national asset." Sproull wryly observed that the best way to get money out of ARPA was "to have a very sexy and powerful idea with an intrinsic and fundamental defect," but very much in the Ruina vein, he insists that supporting such ideas is "still within the role of ARPA and the country is well served by [its] dealing with wild ideas."[24] By 1963, ARPA's research in phased array radar technology also appeared to have peaked. The ESAR work was completed and transferred, and while follow-on efforts continued (e.g., the HAPDAR low-cost phased array and a "synthetic spectrum" radar) they did not appear likely to have quite the far-reaching impact of the original phased array program.

The major thrust of DEFENDER by 1963 was clearly the PRESS program and other related reentry measurement programs and application of the results to the strategic offensive/defensive problems of the Services. The PRESS facility had just come into full operation in the summer of 1963, supported by the complete TRADEX radar and other installations. Tests of various reentry vehicle systems were beginning, including data collection and analysis of the reentry profiles of different vehicle shapes, heat shields, decoys, etc. ARPA's BMD Advisory Committee and its individual members had come to play a significant role both in structuring the DEFENDER program and in serving as consultants to the DDR&E and his staff on BMD matters. New DEFENDER initiatives around 1963 included the start of a high boost interceptor experiment (HIBEX) designed to prove the feasibility of a 100G+ interceptor, and the ARPA Mid-course Optics Stations (AMOS) to examine the role of optical discrimination.

The primary event relating to the VELA program in 1963 was, of course, the signing of the Limited Test Ban Treaty in June. As part of gaining Congressional acceptance of the treaty, the Administration pledged a strong continuing national effort in nuclear test detection research, which served to strengthen VELA's position vis-a-vis the established nuclear test detection community. In addition to reinforcing the legitimacy of the VELA mission, the treaty had a distinct impact on the content of the VELA program. The ban on underseas testing, for example, led to increased ARPA effort on the feasibility of underwater detection stations. More importantly, the obstacles encountered in negotiations leading to the treaty regarding on-site and close-in monitoring techniques resulted in greater emphasis on systems effective at "teleseismic distances." This, in turn, contributed to ARPA interest in large aperture seismic arrays which might be effective at such distances.

The first VELA satellites for detection of nuclear blasts in outer space and the upper atmosphere were successfully launched in 1963. Conceived purely as a research system, with all satellites planned to be launched in 1963/64 and expected to have relatively short lives, the program was to prove successful far beyond initial expectations. Other VELA efforts well underway by 1963 included a large number of fundamental research projects in seismology at several universities, considerable upgrading of the worldwide seismic stations, general rejection of Geneva-type systems as the basis of an adequate detection network, initiation of work on on-site inspection techniques applicable to an underground test ban situation (VELA Cloud Gap), and a start on some evasion techniques work.

The ARPA Materials program was operating smoothly by 1963. The final university interdisciplinary laboratories had been selected and a considerable acceleration of educational and research output was visible. A significant new program in crystal growth was initiated, supportive of the IDL effort.

AGILE was in the realtively calm portion of its stormy career. The program was dominated by research on physical environmental questions (e.g., mobility and communications) in Thailand and by quick reaction hardware projects in Vietnam. Service pressure had begun successfully to reduce the AGILE effort in Vietnam (this prior to the Gulf of Tonkin incident, which led to the massive introduction of U.S. troops and a substantial re-expansion of AGILE work). The subject of counterinsurgency was still rather low priority in DDR&E, finally attaining some recognition there in 1964, when Seymour Deitchman was named Special Assistant for Counterinsurgency. While there were disturbing facets of this program which bothered Sproull, as they had Ruina, the situation in 1963 appeared to be more or less under control.

In the Command and Control Research office, renamed Information Processing Techniques (IPT), emphasis continued to shift from the initial major contract at Systems Development Corporation to work performed by institutions in the Boston area. The latter focal point, capped by MIT's Project MAC, was much more oriented than the early SDC work toward basic developments in computer time-sharing, computer graphics and other advanced research areas which have come to be known as "artificial intelligence." By 1963 the program had achieved the milestone of creating one of the first multiple-user time-sharing systems, the largest of its day. As in other areas of ARPA activity this basic research emphasis appeared to be widely accepted (if not vigorously encouraged) within DDR&E and the DOD in general.

Other areas of ARPA research in 1963 included the new program in Behavioral Sciences research, which was just getting underway. The solid propellants office had actually turned its emphasis away from solids to hybrids and storeable liquids and was proving increasingly difficult to justify as an ARPA program. ARPA work in "energy conversion" also had failed to catch on as a major ARPA program and was on the verge of elimination. Arms control research, which ARPA had resented because it was merely ISA's "silent partner," paying the bills, proved unsuccessful and was being phased out. Research in climate control was curtailed when the House Appropriations Committee eliminated its budget.

In summary, the ARPA program in 1963 consisted of five major research areas which appeared to be thriving (BMD, nuclear test detection, materials, information processing and AGILE), one nascent office (behavioral sciences), and several marginal offices in process or on the verge of elimination (propellants, energy conversion, arms control studies, climate). Budgets exceeded $270 million and nobody seriously questioned the propriety of that level of funding (See Table VI-1).

DEFENDER

During Dr. Sproull's tenure the DEFENDER program reached the height of its acceptance and impact, achieving a stature that stood the program and the Agency in good stead for several years to come. Dr. C. M. Herzfeld, first as DEFENDER's director and then as Sproull's deputy, had provided strong direction to the office and had overseen major reorganization and solidification of the effort. His successor as DEFENDER head, Dr. Samuel Rabinowitz, also proved to be a strong program director. DEFENDER's success was related to several developments both within and outside of the Agency.

First, as long as the Army was pushing ahead with the NIKE-ZEUS program and urging deployment, DEFENDER was naturally regarded as competitive. Indeed it was not only natural, but apparently the result of deliberate policy:[25]

Table VI-1

Program Budget History During The Sproull Period
($ Millions)

	FY 1964	FY 1965	FY 1966
Appropriations Requests	280	283	277
Actual Budgets	274	278	274
Commitments to Agents	280	288	280
Requests By Program:			
DEFENDER	128	128	127
VELA	52	61	59
AGILE	26	30	30
Materials	21	27	28
C&C/Information Processing	13	14	19
Behavioral Science	3	4	4
Advanced Sensors	-	-	5
Propellants	25	9	-
Energy Conversion	6	3	-
Arms Control	1	1	-
Technical Studies	7	8	9

> [T]he oral tradition was very strong ... that ARPA was kept in this because it was found very useful by successive Secretaries of Defense and DDR&E's to have a powerful pacesetter for the Army program and this competition, in fact, resulted in a better Army program. And it also [helped] the DDR&E's and the Secretaries of Defense to manage the Army program and to evaluate it better, by having ARPA in their own shop. Now, this oral tradition, to my knowledge begins ... I know it from the days of Harold Brown and McNamara, not before. It was very strong then and Ruina made it very clear to me [Herzfeld] that that's what Brown and McNamara had in mind. Brown made it very clear to me that that's what he and McNamara had in mind. And McNamara made it very clear to me that's what he had in mind. So, that oral tradition, as far as I am concerned, is complete. And my marching orders always were, well ... you do the best you can and we will know better what to do about the Army.

During the Ruina/Sproull period, ARPA's phased array radar technology developments served to highlight the limitations in the ZEUS radar systems, and thus to undercut deployment arguments. In addition ARPA's emphasis on the gradual and careful accumulation of reentry measurements data which could then be used to improve BMD systems design, while offering no immediate alternatives to ZEUS, implicitly supported a "go-slow" philosophy that tried the patience of ZEUS deployment advocates. The 1964 NIKE-X decision, which committed the Army to phased array technology and postponed system deployment (hence permitting digestion of the results of the reentry measurements work) thus removed two major sources of tension with ARPA.

In addition, indefinite deferral of BMD deployment clearly reduced the status of the ballistic missile defense effort within the Army and made the NIKE-X program somewhat more receptive to the additional support for this technology provided by ARPA. In describing DEFENDER's influential role in the early 1960's, it should be noted that BMD was never truly "mainstream" Army and that, particularly after the NIKE-ZEUS decision, there evolved a sort of "love-hate" relationship between the Army and ARPA BMD programs. While DEFENDER was often an irritant, Army BMD personnel were forced to recognize that ARPA provided a large ($125 million) annual increment to R&D in the ABM field that might well not have been forthcoming had the Army had full responsibility for the effort. The more the Army was pressured to upgrade its non-strategic capabilities for conventional and unconventional warfare, the greater the pressures were to become on BMD funding.

The second major DEFENDER development during Sproull's tenure was the maturing of the reentry physics/missile phenomenology program, furthered by Herzfeld's insistance on a careful, quality measurements program. It opened the flood gates for data on reentry characteristics of different types of warheads. While DEFENDER would accumulate vast amounts of improved data in following years, the early results filled a near-vacuum and hence had a particularly large impact. By 1963 the Pacific Range Electromagnetic Signature Study -- PRESS -- was in full operation at Kwajalein Atoll, with the TRADEX radar beginning to pay-off on ARPA's earlier investments. The AMRAD radar also had become operational at White Sands Missile Range. The flow of data was so great that, according to Aviation Week, significant cost savings could even be achieved in the program:[26]

> Because of the large amount of reentry signature data obtained during the past year, where formerly there was almost a void, there will be increased emphasis during the coming year on analysis of this data and developing theories that will permit more basic extrapolation without the need for so many expensive test shots.

In a third major development, although abandoning lines of BMD research which might lead to an Air Force mission (i.e., BAMBI), ARPA was beginning to exploit its reentry physics and other programs for strategic offense applications of direct interest and value to the Air Force, notably in the penetration aids work assigned by the DDR&E in late 1961. In 1963, for example, ARPA completed an initial compilation of the physical characteristics of U.S. ballistic missile reentry systems, along with an assessment of relevant Soviet AICBM capabilities. This was a landmark document, of major interest to the Weapons Systems Evaluation Group and the Air Force, and was subsequently updated and extended. Computer studies, aided by data coming in from the reentry physics work, examined the effectiveness of various penetration versus defensive tactics. Nuclear effects studies examined the vulnerability of offensive as well as defensive systems. In May 1964, ARPA's BMD Advisory Committee initiated the mammoth "Pen-X" study, which examined the whole penetration problem in great detail and proved to be one of the most influential studies conducted under the DEFENDER program.* Thus DEFENDER had by 1963-1964 considerably broadened its client base and was no longer simply an advanced BMD program.

* IDA coordinated this study and others like it, drawing on a wide range of talent in government, the universities, not-for-profit organizations, and industry.

The structure of the DEFENDER program in the 1963-1964 period was as follows:

1. General Research. A sort of miscellaneous category covering basic university research in atomic and molecular reactions; "exotic applications" to BMD such as lasers and charged particle beams; nuclear effects studies of offensive and defensive applications; and the Arecibo Ionospheric Observatory. Arecibo, which led a life of controversy in ARPA, was enjoying something of a "honeymoon" in 1963-1964, finally becoming operational on November 1, 1963.

2. Penetration Aids. This effort included the work noted above, in addition to studies of jammers, decoy systems, etc.

3. Electromagnetics. This was basically the advanced radar program, which included the ESAR project until its phase-out in 1963. The element also included the Advanced Design Array Radar (ADAR) effort, devoted to extending phased array component technology for application to deployable systems of the 1970's; the Hard Point Defense Array Radar (HAPDAR), a model low cost phased-array; a synthetic spectrum radar, designed for high resolution in range and velocity; and high power microwave tube development.

4. Mechanics. This element included the ARPAT program, which was dominated by the ARPA Measurements Radar (AMRAD). It was turned over to Lincoln Laboratory for use in the measurements program in December 1963. The Experimental ARPA Interceptor (EAI) program was another part of the effort, gradually supplemented by the vigorous new HIBEX aimed toward a state-of-the-art advancement in interceptor technology.

5. Missile Phenomenology. This element was the heart of the DEFENDER program, claiming over half the total budget. The core work effort was Lincoln's PRESS program, but the effort also included the ARPA Midcourse Optical Observatory (AMOS) which supplemented the PRESS radar data with optical data; a reentry experimental program relating to offensive reentry vehicle design, conducted in conjunction with the Air Force ABRES program; and a missile launch phase phenomenology program called TABSTONE.

To illustrate the magnitude of the above effort, the annual DEFENDER budget in the 1963-1964 period was about $125 million, out of a total budget of about $280 million. About half of the total DEFENDER budget related to reentry physics and missile phenomenology. Of this, over $20 million per year was in the PRESS program. The established prominence of PRESS was to continue throughout the life of DEFENDER: total PRESS expenditures accumulated to over $230 million, or about the amount of an average annual ARPA budget. Expenditures on PRESS were over three times those on phased array radar development, and about ten times those on Hibex, Arecibo or the AMRAD radar. Herzfeld has explained the rationale for this decision:[27]

> I very much increased the percentage of work in reentry physics, and the reason for that was both the need to really sort out the discrimination problem and by that time it was pretty clear that was going to turn into a reentry problem. And also it was needed for the penetration aids job.... So I would say I sort of doubled the percentile, the monies going into reentry physics, from, I would guess, $20 to $50 million a year, which turned out to be almost half the program.... [I]t got very clear when I was still at ARPA, but had left DEFENDER, that that had been right. In fact, we wound up with a program that really understood -- wound up understanding reentry phenomena almost completely, both from a ... scientific point of view and from a very detailed measurements point of view.

Changes in DEFENDER Philosophy. In the early DEFENDER years, the program was notable for its exceptional responsiveness to outside ideas. The most obvious example of this was the so-called GLIPAR program, in which a large number of contractors were requested to submit proposals to study very advanced BMD concepts. DEFENDER constantly reasserted its interest in unsolicited proposals, specifically encouraging industry to submit such proposals to the extent of printing the ARPA mailing address in the trade press for ready reference.

The early DEFENDER approach is perhaps best described by Dr. Albert Rubenstein, who directed the DEFENDER program during the Betts and early Ruina period.[28] The ballistic missile defense problem was, in his view, still in the exploratory, learning, problem-definition phase, not yet worried about optimizing BMD solutions. The problem was that DOD was "way behind the power curve" in understanding BMD problems, and there was a sense of great urgency to improve understanding. Rubenstein claimed that, given this urgency, three basic questions were asked in considering projects: did the proposal "look reasonable;" were the dollars available to "match up;" and could you find a competent firm to "sort of watch it?"

By the time of the Sproull directorship, this wide-open responsiveness to outside ideas was largely gone. First Ruina, and then Dr. Herzfeld and Rabinowitz regarded the earlier approach as much too loose and disorganized. As Rabinowitz put it, the decision criteria in the early days was "to sit around and wait for ideas... if, in 15 minutes, you can't show that it won't work, given them a contract."[29] In his opinion, ARPA got little out of this. The approach which gradually replaced this was described as follows: "Who knows more of this than the people in ARPA and its bevy of high class experts? ... let's decide what we want to do and then go get industry to do it for us."[30] Consequently, the

DEFENDER program began to engage in more internal program planning and definition of requirements and to put increased emphasis on RFP development and competitive procurement. Later programs like the ADAR and HAPDAR radars and HIBEX were thus ARPA-developed concepts, rather than responses to contractor proposals or work inherited from the Services, although ARPA continued to pick the brains of researchers in fields of interest, wherever they were located.

Much of this reorientation apparently was grounded in a DEFENDER philosophy evolved and very gradually introduced into the program by Herzfeld. He was a strong believer in going back to "first principles." Criticisms were often heard within ARPA that DEFENDER wasted money on elegant scientific frills (discussed further below), but the DEFENDER program deliberately sought to differentiate itself from others by its insistence on a deliberate, scientific approach to BMD problems:[31]

> [T]he gross phenomena in reentry are so complex and so multifarious that you cannot count on capturing what's really going on by a purely Edison-type research, a purely serendipity-type research. You have to try and understand what are the things that make it go the way it goes. Otherwise you cannot have any confidence that you've caught it all. If you've not caught it all, you cannot promise anybody that the other fellow isn't going to have a defense.... So we set out to verify as much as was reasonable on the basis of laboratory experiments in shock tubes, in ballistic guns indoor laboratory ranges, with calculations with atomic and molecular theory, hydrodynamic theory. That's what the physics program was. And I tried to force -- that was one of the things that I think I added. I think it did make a difference. I tried to force that we try to understand as much as we could, reasonably, from first principals. And then we could say "a high temperature ablating nose cone will always do the following," because you would simply know that it had to, because the laws of nature were involved. It wasn't a matter of being clever about it. And then we could say "all right, in that case we only have to fly five big ones instead of 50 big ones, to explore all the possibilities. Thereby saving large amounts of money. You see, people didn't understand that this relatively

> cheap program -- it was like 10 per cent of the whole reentry program as I remember, maybe a little more -- avoided the need of flying an enormous number of full-sized targets. Because we would understand what was happening, and we could predict with adequate confidence what would happen if we changed a little bit.

If DEFENDER had moved from a posture of depending primarily on responsiveness to outside initiatives to greater internal direction during the early to mid-sixties, the quality of this internal direction appears to have been held in generally high regard from Herzfeld and Rabinowitz down through their carefully selected staff. Spokesmen for Lincoln Laboratory, for example, state that:[32]

> ARPA had first rate people who made great contributions to defining issues and got into technical detail, but did not over-manage ... ARPA was so good intellectually and technically ... [they] were different levels of people [than the normal bureaucracy].

They went on to say that the DEFENDER staff "knew how to communicate the real technical issues" and were not adverse to taking "heroic measures" to support their technical judgments: "A PRESS-like program could not happen today because nobody will run the risk of starting out, not knowing whether there will be any results."[33] The DEFENDER staff, they felt, had the ability to "sense winners" and get behind them. Dr. Foster, who as DDR&E came to be quite critical of ARPA management, remembered the DEFENDER program of this period as being "unique" and "a tremendous contribution."[34] Rechtin, the man tasked to dismantle the DEFENDER program in the late 1960's and a person who believed that in general ARPA had become too far removed from appropriate association with the Services, praised the DEFENDER reentry physics work as "fundamental ... remarkably good;" indeed, so good that the Services recognized it as unbiased and high quality.[35] While these are varying views of the ultimate importance of DEFENDER, the consensus opinion appears clearly to be that the program and staff of this period were of unusually high calibre.

<u>The Limited Threat ABM Study</u>. Illustrative of the kinds of studies undertaken by ARPA over the years for the DDR&E and/or Secretary of Defense, was a 1964 assignment from McNamara for ARPA to examine "light" BMD systems and assess their value against various potential threats (e.g., an unsophisticated Chinese nuclear attack, or a limited, perhaps accidental, Soviet attack). As Sproull remembers, the study assignment came "out of the blue" and he initially expected it to be a very limited study effort.[36] It was, however, developed by the DEFENDER staff

(with OSD/DDR&E approval) into a rather immense study, somewhat akin to the massive "X" series of studies referred to elsewhere.

Like many paper studies, the influence of this effort is difficult to trace. The contemporary head of the DEFENDER program recalls boiling down the results of volumes of work into a twenty-five page memorandum describing feasibility and cost effectiveness issues, which was transmitted to the Secretary.[37] There was apparently some confusion over the implications of the ARPA study, but it evidently concluded that a "light" ABM system might be effective in certain situations. To cite Sproull's declassified Congressional testimony:[38]

> In our study of the defense of the U.S. urban population against limited ABM threats; i.e., threats which were small in number [deletion] and relatively unsophisticated in technology, we considered a wide spectrum of attack sizes and offensive and defensive technologies. We concluded that a limited deployment of NIKE-X [deletion] would be extremely effective in countering such a threat.

After some initial debate over the study's results, discussion of the issue faded away.

In 1966 and 1967, however, the issue of whether to deploy some form of limited ABM system was to become a matter of national policy debate, eventually resulting in a decision to deploy a "light" system in the form of SENTINEL (a decision which ultimately led to the transfer of ARPA's DEFENDER program). In the course of the SENTINEL debate issues which had earlier been considered in ARPA's classified study were vigorously discussed in public forums, and new rounds of classified studies relating to the issue were undertaken. Dr. Herzfeld, by then Director of ARPA, became a vigorous spokesman for a light ABM system: [39]

> If such discussions [negotiations with the Soviet Union] fail I am in favor of deploying a thin ballistic missile defense, mostly a high altitude system to cover most of the United States, and in particular to cover our ballistic missile sites.
>
> I think we would know how to do that fairly rapidly and at a reasonable price. I think there are a number of technical uncertainties, but there are in every system. When you start deploying a system you never know everything about it. Something new always crops up that you hadn't thought

> about and you have got to go through a study phase to catch up with the problem. I think though we could do that, and that we know enough to go ahead with the kind of system which I described....
>
> The kind of system I think we could deploy would be quite effective against small attacks, and therefore would reduce danger from an attack by China to almost nothing. It would be very effective against accidental attack. It would be very effective against blackmail attacks....
>
> I think one could do reasonably well with \$10 billion, maybe \$12 or \$14 billion. If you stretch it over a period of 5 years, it isn't all that much money really.

In the course of the debate leading to SENTINEL deployment technical issues addressed in the earlier ARPA effort were reinvestigated, and it seems fairly certain that the massive 1964-65 effort contributed substantively to this reexamination. The positions of pro-"light system" spokesmen such as Herzfeld were probably influenced substantially by the ARPA effort. In the end, however, purely political considerations played the major role in the Sentinel decision and it is therefore virtually impossible to ascertain the impact of the ARPA study, or to separate its influence from the numerous later technical investigations. Individuals familiar with the ARPA program differ sharply on its influence.

The Arecibo Ionospheric Observatory. While the DEFENDER program was flourishing under Sproull, it was far from uniformly non-controversial. One of the contemporary criticisms of the effort, which later became a serious attack on the Agency itself, was that it was too tolerant of activities that were overly academic and not contributory to the central program mission. This was, in effect, a rejection of the Ruina ranking of quality over relevance. Perhaps the one DEFENDER program which best exemplifies this issue is the Arecibo Ionospheric Observatory, which like many other efforts was enjoying a honeymoon in the Sproull period. The Arecibo facility became operational in November 1963 and throughout the Sproull directorship proceeded to generate vast amounts of data relevant to ionospheric research, radar astronomy and radio astronomy. This explosion of data from a new and unique scientific facility proved merely a prelude to its continuing major role in such fields and the facility was transferred to the NSF in 1969 to become the Arecibo National Radio Observatory. Nevertheless, despite the fact that the facility was to become a clear asset to American science, it was never established to be especially relevant to the DEFENDER program (or any other major DOD concern) and it served as a long-standing, glaring example of ARPA's inability to shed commitments of questionable priority. An idea first broached to ARPA in late 1958, ARPA money was still supporting the program in 1971 (as part of the NSF transfer process), a period of almost thirteen years of ARPA involvement.

Stepping back from the Sproull years to its origins, Arecibo may be seen as one of the many basic science-infrastructure development programs which gained government support in the wake of Sputnik. The project was conceived by Cornell University and involved construction of a one thousand foot diameter fixed radio/radar "dish" to be installed in a natural depression near Arecibo, Puerto Rico. Shopping for federal support, Cornell approached the Rome Air Development Center, which in turn brought the idea to ARPA in November 1958. The concept was reviewed by ARPA's IDA staff, which wrote papers justifying its support.[40] The program was eventually endorsed by ARPA and incorporated into the DEFENDER effort in 1959.

The official rationale for the program was its alleged contribution to ionospheric studies, particularly studies of electron density at higher altitudes, which might isolate phenomena which would be produced by a passing missile or reentry vehicle. Such phenomena could then presumably be utilized in a BMD detection system. In addition, improved knowledge of the ionosphere could contribute to nuclear effects studies relating to that environment, nuclear effects, of course, being a major concern in the ballistic missile defense environment. Beyond these reasons, some extraordinarily far-fetched applications were suggested, related to the GLIPAR program:[41]

> One should ... [with the Arecibo dish] be better able to compute the temperature, densities, and energy content of the associated ions and neutral particles. Some of the ideas in GLIPAR depend upon knowledge like this to be able to estimate if and how one might modify the earth's atmosphere to trigger strong deflection, or even destruction, of offensive vehicles.

Despite these proposed BMD applications, it was clear from the beginning that no one outside of ARPA who supported building and operating this facility did so with any interest in ballistic missile defense problems. This is indicated in a marvelously contorted fashion in one of the early IDA memoranda:[42]

> The following meetings are documented to illustrate the breadth of discussion and support which has developed outside ARPA in connection with the vertical sounder proposed by Cornell University, with 1000' fixed dish in Puerto Rico. It should be expressly noted that none of the individuals or organizations identified below have the additional stimulus which ARPA does have of primary responsibility for advanced ballistic

> missile defense. Even so, the unanimous feeling which we have found outside ARPA is in favor of the construction of the facility and the performance of the recommended experiments.

In other words, the fact that the project's advocates were not interested in ballistic missile defense was used to buttress the case for its inclusion in the ballistic missile defense program!

As if to strengthen a relatively weak case for the facility on BMD applications, numerous radio astronomy uses are cited in the early IDA statements. These included mapping the moon and sun, studying planetary rotation and "listening intently to the quiet hum of the universe in many of its tell-tale undertones and overtones."[43] These applications clearly had little relevance to the DEFENDER mission, but did underlay the science community's interest in the project.

The rather weak case on paper for Arecibo's inclusion in the DEFENDER program is confirmed by interviews with participants in the decision to support the program. One of the IDA staff members at this time, for example, states in retrospect that "We had no right to do Arecibo, and we knew it, but we did it for the sake of humanity."[44] The rationale was that the project was scientifically important and "nobody's going to do it unless we stick our necks out." After ARPA decided to support the project, "We cobbled up an explanation that none of us believed had much to do with ballistic missile defense."[45]

The Arecibo program was controversial from the beginning, and remained so into and well beyond the Sproull period. William Godel, for example, asserts that he "fought, bled and died against it" from his policy planning position and as a member of the Program Council, but to no avail.[46] As the project got underway and construction began, Arecibo's merit came under increased attack. As Dr. Ruina recalls "[I]t was beginning to be rather costly and Cornell was managing the construction part of it badly ... there were just some terrible things that were happening on construction. The DEFENDER people found it less and less interesting as a DEFENDER experiment."[47] Management people like Bolton and Hess considered ARPA's sponsorship of such non-relevant basic research under cover of military R&D as something of a charade. Even other technical staff within ARPA, occasionally criticized by the Director for asking for more money for what they deemed was important military R&D, were angered and depressed by the ease with which large sums were "squandered for science" in DEFENDER, VELA and to some extent the IDL's. Arecibo, of course, was the prime example.

On the other hand, Ruina and the DDR&E, Dr. Brown, continued to support the project:[48]

> ... if you were talking to Cornell people and people in astronomy, and visiting the facility ... [you] came back with the feeling that it was going to be an extremely important scientific experiment.... It was going to be one of the nation's important scientific facilities.... It would be fantastically important.... At the same time I went to Harold Brown ... and said 'you know, I can't defend this on the basis of DEFENDER targets, but it's going to be an interesting facility,' and he supported us.... Later on, Harold visited the place and came back saying he thought that's just the ideal project that ARPA should be working on -- you know, something that has no immediate applications that the Services are immediately interested in, but some terribly important applied science.... True, the National Science Foundation [should perhaps have supported it] in a rationale world. I say 'what's the rational world?' If we weren't going to do it, nobody was -- and that's all there was to it.

Arecibo in fact is Ruina's favorite example of the sort of important research that ARPA should support regardless of Defense relevance.

When Dr. Sproull became ARPA Director, Arecibo had survived its difficult construction phase and, as noted, soon became operational. As results began to flow from the facility, however, it rapidly became obvious that the instrument's scientific contribution to radio astronomy would, indeed, overshadow any BMD value. The FY 1964 ARPA Annual Report, for example, discusses Arecibo by noting in passing some "significant data" on ionospheric electron distribution (which related to BMD interests) and then highlights its radio astronomy achievements:[49].

> As an astronomical tool, the Observatory has obtained outstanding results during the past six months from planetary and lunar radar studies. Of particular importance is the measurement of Doppler bandwidth of radar returns from Vensus which clearly confirm a JPL conclusion that the rotation of Venus is retrograde with a period near 266 (earth solar) days. Furthermore, the Observatory promises to give the orientation of the axis of rotation of Venus. Measurements of range of both Venus and Mercury show systematic errors in the best known ephemerides of these planets and, since the radar range accuracy exceeds one part per million, improved orbital parameters for these planets and an improved

value for the astronomical unit will be deductible.

Dr. Sproull, in assessing the program, states candidly that Arecibo generated considerable information on the ionesphere which provided some "background" for BMD discrimination research, but on balance was "not all that useful for Project DEFENDER."[50] Because of this limited relevance and continuing contractual problems with Cornell, Sproull became interested in transferring the program to NSF (and later participated in talks to persuade that agency to take it). Despite the fact that ARPA had completely absorbed all of the construction costs (some $10 million) and that annual operating costs were only about $1.5-$2 million, it took four years from the end of the Sproull directorship to conclude an ARPA-NSF transfer agreement and some six years before ARPA ceased funding a major part of the effort. Given these difficulties in transfer, Dr. Herzfeld was to cite as a major accomplishment just keeping the facility alive, because the alternative to transfer was cancellation of federal support.[51]

The latter years of ARPA support for Arecibo were to be filled with controversy and considerable bitterness. The facility became an issue in an OSD audit of DEFENDER, which attacked the continued ARPA support on grounds of relevance. Cornell mobilized academic support for the project. "ARPA is ruining basic research" stories appeared in the Washington Post after ARPA decided to reduce its support. DEFENDER staff members came to feel that the Arecibo group did not make even a token effort to establish greater Defense relevance, but insisted on a blank check for the facility which, in effect, asked ARPA "to ignore the law."[52] Later ARPA Directors (including Acting Director Franken, who was much inclined to support basic research)[53] came to regard transfer as a practical necessity, but protracted and frequently strained negotiations were required to accomplish that event. In the end, well over $20 million dollars of ARPA funds went into Arecibo.

The Arecibo project in the Sproull period symbolizes a fundamental dilemma in ARPA's history. By 1964-1965 Arecibo had established itself as a magnificent success as a scientific development. In these and subsequent years major contributions were made to radio astronomy-planetary studies, research on cosmic radio sources, investigation of quasars, pulsars and "black holes," mapping of supernovae, studies of planetary nebulae and remote galaxies, and many other developments. As was clear at the time and was confirmed by the tortuous process of transfer to follow, Arecibo would not have taken place without ARPA and its ability to find a "critical mass" of funds for large scale scientific projects which did not have immediate applied payoff for operational agencies. On the other hand, it was beginning to be recognized as early as Dr. Sproull's period that scientific opportunity did not always correspond to defense relevance, even broadly defined, and that ARPA was in a vulnerable position in supporting work more logically the responsibility of a national science agency, even if this role fell to it by default of existing institutions. Arecibo thus raises in especially clear terms the problem of weighing technological achievement versus more direct contribution to Defense missions in assessing the role and value of ARPA.

VELA

By 1963-1964 the VELA program had changed little in basic content, but had undergone a further reorganization. VELA Uniform (underground test detection) continued as a major element, but the function of developing techniques for inspection of clandestine underground tests was split off as a separate program element, named VELA Cloud Gap. This change reflected the U.S. posture in test ban negotiations that some form of on-site inspection would be necessary in any comprehensive test ban and the consequent desire of the Arms Control and Disarmament Agency to expand research on inspection techniques. Giving on-site inspection research separate program status within VELA thus responded directly to ACDA requirements.

While this additional program element was created, the total number of branches within VELA remained at three by the merger of VELA Sierra and VELA Hotel into a new element called VELA High Altitude. Sierra and Hotel had been oriented toward detection of high altitude explosions, one by surface-based means and the other by satellites, so the merger appears to have been a logical consolidation. The decision to merge probably reflects the fact that VELA Sierra was one of the smaller program elements and that VELA Hotel had come to be dominated by one major project, the VELA Satellites, which was proceeding very smoothly (the third and fourth satellites were successfully launched in July 1964). Relatively light management burdens in the separate offices may thus have suggested consolidation.

Within the largest program, VELA Uniform, some significant changes were beginning to take place. The Worldwide Standard Seismological Network program had successfully upgraded some one hundred seismic stations around the world and transfer of continuing responsibilities to the U.S. Coast and Geodetic Survey was planned for FY 1965.* Concurrent with the planned transfer of this program, VELA received a new mission in the area of underwater test detection inspired by the ban on this form of testing as part of the Limited Test Ban Treaty. ACDA was much involved in the development of this program and in fact had officially proposed to the Soviet Academy of Sciences that the later stages of research become a joint program.

Elsewhere in VELA Uniform, testing of modified and expanded Geneva-type detection stations continued and investigations of new types of

* This transfer was delayed substantially.

seismic detection stations went forward. By the first half of 1964 ARPA had developed a special interest in a radically new type of seismic station, the so-called large aperture seismic array (soon known by the acronym LASA). The LASA program was to become a major and highly controversial project within VELA through the next three to four years. During Sproull's period it appeared that the program might achieve a dramatic breakthrough in underground detection capabilities.*

Other major work efforts within VELA included research on the value of seismographs implanted in deep holes (designed to reduce seismic "noise"), research on the seismic signatures of nuclear tests conducted in environments differing from the normal Nevada test sites (ARPA sponsored two underground test projects name SHOAL and DRIBBLE), and increased investigation of the requirements of seismic arrays operating at "telseismic" distances (e.g., 2000 to 10,000 miles). This latter shift in research emphasis was directly responsive to changes in the U.S. position on an underground test ban, which by 1963 had come to place reliance on "national monitoring systems" -- that is, systems directly under the control of one nation or a group of allied nations -- rather than international test detection arrangements as envisioned in earlier Geneva discussions. Whereas Geneva-type systems emphasized stations relatively close-in to potential explosions (under 1000 miles), reliance on national means of verification entailed greater dependence on remote stations, with distinctive technical constraints and potentials.

ARPA funded basic research in seismology at levels orders of magnitude higher than researchers in this relatively neglected field had known. Sproull described most of the instruments in use as "Dark Ages instruments, almost 18th Century" and he is among those who believe that ARPA revolutionized this science: VELA made "all the difference in the world in the field of seismology."[54]

In summary, the relatively modest organizational changes within VELA concealed rather substantial substantive changes, which were largely conditioned by the signing of the Limited Test Ban Treaty and developments in the U.S. posture regarding a more comprehensive treaty. Sproull's conviction that ARPA played a key role in the decision to sign the Limited Test Ban Treaty was noted briefly above. It is important because his judgment places ARPA squarely in the midst of a Presidential policy issue, relates ARPA directly to serious concerns in the Services and suggests positive implications for the Agency's standing in general: [55]

* LASA is discussed in detail below in Chapter VII.

> I don't think there would have been a partial nuclear test ban treaty if it hadn't been for ARPA's work.... It is true that the President wanted it, but he couldn't get it [unless] the Joint Chiefs stood up and said 'we can assure the safety of the country with this'.... And I don't think that could have been done without the ARPA work.... The fact that Project VELA had in the works things like the satellite thing. And could, with a certain amount of believability, know what those things were going to do... and how ARPA was going to keep goosing the technology and make sure we were out there in front and so on. That was more important, I think, than any single thing....
>
> The Joint Chiefs, and through them, the Congress was relying not so much on any particular piece of knowledge that ARPA had produced -- although there was a lot of that in those hearings that spring -- but on the fact that here was an agency that was believable and one you could trust.... [T]he way that Jack [Ruina] and his people testified on the VELA Uniform end of things, I think had a fair amount to do with the believing of the Agency on the other environments. If they had exaggerated and said things that weren't credible ... then I don't think the whole thing would have gone through....
>
> ARPA came out as a kind of honest broker, technical ... cautious optimism ... people whose [participation] gave some credibility to the fact that they would be able to do what they said.... Frank Long and the other ACDA people [on the other hand] could say the same thing and not get away with it. ARPA could say it and it had to be believed.... ARPA had established itself as believable... and not the captive of any one point of view ... and partly because of the actual work that had been done by ARPA contractors, the Joint Chiefs were able to do things they could not possibly have done without it....

The VELA Satellite Success. One of the most glittering success stories of the Sproull years, or perhaps more fairly the Ruina-Sproull years, was the VELA Satellite program. Technically, the program attained accomplishments beyond all expectations. Bureaucratically, the satellite effort was applauded by the Secretary, and regarded as an outstanding achievement by the Service participants (ARDC, the agent, and the Space Systems Division of the Air Force Systems Command). It meshed smoothly with the Atomic Energy Commission, whose Los Alamos Scientific Laboratory designed the detector instrumentation. During a period of increasing concern over rising R&D costs and procurement procedures, the VELA Satellite program was cited as an outstanding example of cost savings based on incentive contracting, which brought out the best efforts of private industry (in this case, TRW) while substantially rewarding industry for superior performance. Indeed, the primary point of debate over the VELA Satellite program appears to be whether ARPA could, or should, have taken advantage of the early pre-1965 successes to transfer the program to the Services. That issue, however, will be addressed in a later section of this history.

To begin to get a feel for the magnitude of VELA Satellite's success in this period, one should note that early plans called for a program of nine satellite launches between June 1962 and July 1964 at a cost of $104 million, just to establish the feasibility of detecting nuclear explosions in outer space. Severe doubts concerning launch vehicle and satellite reliability accounted for the number of launches estimated. It was a very realistic estimate given the record of launch vehicles in the late 1950's and early 1960's. By mid-1961 the program had been extensively revised to provide for a more sophisticated detector package and a different set of launch vehicles, but plans still called for ten satellites to be launched in pairs of five vehicles at a cost of some $67 million. Again, there were serious doubts about reliability and the entire set of launches was to take place over a two year period (spaced three months apart) purely to test the feasibility of detecting outer space blasts. Prior to the first satellite launch the estimated cost of this feasibility experiment had risen to approximately $80 million.

In fact, however, the first satellite launching and flight (just after Sproull took office) worked perfectly and completely satisfied the feasibility requirement on the first launch. By mid-1965 the first satellite pair had tripled their specified design operating time and continued to provide useful data (on a gradually degraded basis) for some time thereafter. This success enabled later satellites to be redesigned for upgraded capabilities and for added missions and permitted launches to be stretched out through 1969 (with an additional launch of back-up satellites added). The initial success and consequent shift of later satellites from mere feasibility test objectives was estimated at the time to have saved the DOD approximately $26 million.

The final cost of the vastly expanded and reoriented VELA Satellite program at time of transfer from ARPA in 1970 is estimated to have been $155 million. For less than double the last pre-launch estimate of the cost just to test feasibility (far less considering inflation), the

VELA Satellite program provided an interim operational capability to detect possible outer space tests well into the 1970's -- over a dozen years -- <u>and</u>, as the program was reoriented to also detect and provide diagnostic information on atmospheric tests, an adjunct to U.S. intelligence capabilities in an environment where testing (e.g., French and Chinese) actually continued to occur. The program was clearly a major success on both technical and cost effectiveness grounds.

That VELA Satellite was acknowledged to be a major achievement at the time of its initial successes is reflected in Secretary McNamara's July 7, 1964 report to the President on the Department of Defense Cost Reduction program, citing the role of incentive contracting as largely responsible:[56]

> Because of the more detailed advanced planning required -- and the profit rewards and penalties provided by incentive contracts -- contractors are more strongly motivated to achieve superior product performance and to meet delivery objectives. This fact is widely recognized by the contractors themselves. A recent case is the contract for the VELA satellite, used to detect nuclear detonations in space, in which the contractor's incentive fee was based on a number of performance factors including the length of time the vehicle performed satisfactorily in orbit. As a result of the spectacular length of life of the first launch, the Air Force was able to reduce the total program cost 32% -- saving of $26 million. The contractor earned $115,000 in additional fees.

TRW (Space Technology Laboratories at the time of the original contract award) also basked in the glory of this successful "Cost Plus Incentive Fee" (CPIF) contract. In a company publicity release entitled "Success Story: Nuclear Detection Satellites," TRW stated:[57]

> TRW Space Technology Laboratories won the bid for this system in December 1961 and suggested a CPIF contract instead of a CPFF. It elected to forego the customary fee for the opportunity of making a greater profit at a higher risk as offered by a CPIF contract. The contract negotiated with the Air Force at this time was precedent-setting. It marked the first time that an incentive contract based on performance in orbit had been signed....
>
> Four performance incentives were established:
>
> <u>Reliability Test</u>. Each of the ten flight spacecraft undergoes a [illegible]-hour test in a thermal-vacuum

> chamber to establish the flight worthiness of the spacecraft. TRW/STL wins twenty-five thousand dollars incentive fee for each spacecraft which successfully passes this test; and is penalized twenty thousand dollars for each spacecraft which does not pass this test.
>
> TRW/STL has passed four of these tests and failed none....
>
> Controlled Error. TRW/STL stands to be penalized for failing to establish or failing to perform established procedures in the launch operations if this failure results in a one-day slippage of the launch. Each controllable error represents a five thousand dollar penalty with a maximum of two to be assessed per each launch operation. TRW/STL participated in the first launch operation with no controllable errors.
>
> Early Demonstration. An incentive provision was established for successfully placing both spacecraft into the prescribed circular orbits, i.e., separation of the tandem stack; separation of each spacecraft in the tandem stack and successful orbital injection. TRW/STL accomplished this sequence on the first successful booster flight and won one hundred twenty-five thousand dollars.
>
> Life in Orbit. The final performance incentive is a function of the lifetime of both spacecraft in orbit. TRW/STL won maximum on the first attempt, $100,000.

The Air Force was equally enthusiastic about the program. ARPA's old adversary, General Schriever (then Commander of the Air Force Systems Command which managed the VELA Satellite program) commented at the time of the third launch in 1965:[58]

> The four spacecraft are not only providing the necessary background radiation data and scientific information on solar phenomena, but actually constitute an excellent test ban monitoring capability with the R&D satellite configuration. Success of these first two launches has enabled us to move the R&D program ahead by more than a year and thereby achieve cost savings. In the next (today's) NDS launch the two basic satellites will have significantly greater detection capability than the first two.

What was ARPA's role in this extraordinary success story? While credit must be spread among the Air Force, TRW and the AEC (including the Los Alamos and Sandia Labs), ARPA's influence and management approach do appear to have been central.

First, the success of the CPIF contracting approach was not automatic (as could be established by a survey of other such contracts). TRW gave credit to the original Request For Proposal, which "contained a well written, clearly defined technical statement of work which sharply defined the requirements of the system and left the details of implementation to the contractor."[59] TRW added that the excellent guidance provided was confirmed by the fact that very few contract change notifications were required. While ARPA appears to have left the development of the CPIF contract to the Service agent and TRW (and, in fact, was not initially enthusiastic about TRW's selection),[60] it did provide the mechanism which enabled clear specifications to be written into the contract and distinctly separated the functions of TRW and the AEC laboratories. This mechanism was the Joint Technical Group set up in 1961 by ARPA, with representation from the AEC laboratories and the Air Force Space Systems Program Office and chaired by the Air Force program director. The group set technical policy on the integration of the spacecraft and sensors, which led to the development of the RFP and provided continuing guidance throughout the program. ARPA played the role of "honest broker" in assuring the full participation of the agencies and contractors involved and in fostering a "community spirit" which is very much in evidence throughout the period. Without ARPA playing its middleman role, it appears very doubtful that the level of organizational cooperation resulting in clear, realistic guidance to TRW and the AEC labs could have been achieved. An additional TRW comment is also relevant:[61]

> Decisions were made rapidly, usually at working group meetings with SSD and Aerospace in attendance, where the groups were allowed to work out their problems among themselves and present the various alternatives and recommendations for approval.... These are strong groups managed by strong people. With misdirection or lack of direction, a troublesome amount of technical rivalry and nonproductive endeavor could have developed. However, the program has existed without any in-fighting or jockeying for position. All efforts have been expended in the execution of the mission.

A second aspect of ARPA's management of the program was (as previously cited in the DEFENDER context) that it did not over-manage. There was a direct line between the Air Force project director and the ARPA program manager, and an effort was made to minimize red-tape and unnecessary contractural changes. ARPA served as a buffer to the Air Force on budgetary and administrative matters, and used the short line of command to the Air Force project director to dispose of many issues quickly and often informally. This flexible, non-bureaucratic approach is often cited as an ARPA virtue and is much in evidence in the VELA Satellite program.

Third, and perhaps most important, it was ARPA -- and not the Air Force or the AEC -- that made the key decisions following the initial launch success to stretch out the program and extend its objectives beyond feasibility testing. Within one month of the first launch, the second satellite pair was delayed six months, and the third scheduled for nine months after that. Concurrently, several modifications were made in the instrumentation for the second satellite pair, and major technical advances were incorporated into the third. These changes were essential to enable the VELA-Satellite program to serve as a good interim operational capability into the 1970's. To the Air Force alone, however, the succeeding launches would have been neither fish nor fowl -- neither a purely research endeavor nor a full operational system -- and it is likely that the program would either have been continued on its earlier schedule (with greatly reduced cost effectiveness) or curtailed (leaving a gap in monitoring capability or resulting in crash development of a full operational system). In fact, the Air Force initially opposed program stretch-out and later proposed the development of an alternative operational system (which was rejected by DDR&E). [62] The character of the follow-through on the initial R&D program success was thus directly dependent on ARPA decisions.

The success of the VELA Satellite program in the Ruina-Sproull period thus reflects many of the attributes cited in justifying ARPA's role in general -- its ability to support multi-Service efforts (here, really, multi-agency) and its role as a source of neutral technical guidance, its lack of internal bureaucracy, and its flexibility and ability to respond rapidly to changed circumstances.

This role was strengthened by a number of favorable events only partially noted above. The success of the CPIF contract was buttressed by considerable interest in such contracts as a solution to procurement problems. In an era of TFX and other procurement controversies it was certainly in the Air Force's interest to be supportive of a promising innovation. The VELA Satellites were expected to yield data of general scientific importance on radiation in space; hence the program was technically "respectable" and could attract quality people. TRW/STL had also just been freed from its long-standing "hardware ban" -- the VELA project was its first major hardware contract for the Air Force -- hence it had substantial motivation to push for quality performance apart from the CPIF incentives. The program happily coincided with major improvements in the reliability of launch vehicles, which rendered earlier plans conservative and infused great program flexibility. The original commitment to developing means of detecting nuclear tests in space, growing out of the Geneva negotiations, was strongly supported by the signing of the Limited Test Ban Treaty and subsequent commitments to Congress that research to improve national verification capabilities would be pursued aggressively (the so-called safeguard "d").

In summary, the success of the VELA Satellite program in the early 1960's appears to be an example of the application of the classic ARPA role in a setting most conducive to a successful outcome.

AGILE

Recalling the modest early descriptions of AGILE, a glance at project organization and budget in 1963-64 quickly reveals that this program had changed considerably by the time Dr. Sproull became director. By FY 1963 AGILE had become the third largest project in ARPA, following DEFENDER and VELA, but now larger than the propellants and materials efforts and much larger than the nascent information processing and behavioral sciences programs. Its $23.4 million budget was now a third the size of the VELA effort and a fifth of DEFENDER, compared to a sixth and a tenth, respectively, in FY 1962. These figures are especially impressive given the major hardware expenditures in both DEFENDER and VELA (e.g., radars, satellites, etc.). AGILE had indeed grown into a major ARPA commitment.

Equally as impressive as the budgetary growth in AGILE is the rapid expansion which had occurred in the scope of the program effort. Whereas AGILE in FY 1962 was conceived narrowly as the Southeast Asia combat test and development centers, i.e., as two field offices in Saigon and Bangkok and some supporting research for those offices in the U.S., the FY 1964 AGILE was titled "Remote Area Conflict." Its described purpose was no longer limited to "counterguerilla warfare in Southeast Asia," but rather had become "support of local forces who are in remote areas of the world and who may be engaged in conflict ranging from incipient subversion to engagement by conventional forces in limited war."[63] An intent to open new field offices in the Middle East and in Latin America was also announced. Moreover, at the suggestion of Dr. Frederick Seitz, ARPA became involved in lengthy negotiations with India for a joint military R&D program, to include research on the problems encountered by men and equipment operating at very high altitudes in mountainous terrain. This program was all set for acceptance when the Chinese-Indian War intervened and President Johnson foreclosed U.S. involvement. As Herzfeld put it: "[T]hat just crashed. One of our greater failures. We stopped and then it was politically absolutely dead, both in the U.S. and in India."[64]

Whereas in FY 1962 program description of AGILE focussed on specific circumscribed projects, e.g., plastic boats, combat dogs and defoliants, the AGILE program in FY 1964 contains the following broad tasks:[65]

1. The collection and analysis of data on the operational, environmental, and human factors that govern military activities in remote areas.

2. The identification of local requirements for new or improved weapons, devices, or techniques.

3. The development of special equipment and techniques for use in remote area conflict situations.

4. The proof-testing of prototype solutions, if necessary.

Whereas the early AGILE was heavily oriented toward short-term, immediately useful projects -- and the Vietnam office described as exclusively so -- this was no longer true by FY 1964:[66]

> In the past, AGILE activities have been characterized by programs of applied engineering required to solve the more immediate problems of Remote Area Conflict. While AGILE will continue to respond to requirements for immediate solutions, the project has been in the process of being re-oriented during the report period so that its primary mission will be a more fundamental, long-range research and development effort. Included in the new program is an effort directed to the difficult task of the collection and analysis of essential scientific data peculiar to specific geographic areas. This data base, which does not now exist, is necessary to provide a sound basis for solution of many of the problems associated with Remote Area Conflict.

Similarly, whereas the early AGILE had no program structure described beyond the two field centers and specific projects, the FY 1964 AGILE had five major program elements: (1) communications and surveillance; (2) mobility and logistics; (3) firepower; (4) individual combat equipment and combat rations; and (5) operations analysis. In addition, a variety of other projects were carried on, ranging from continuing work on herbicides to research in tropical medicine.

Thus by the time of Dr. Sproull's arrival AGILE was no longer the low-visibility, non-threatening endeavor that it may have appeared to be at its creation.

President Kennedy was assassinated about three months after Sproull's arrival. AGILE seemed to hold its own while he was alive and Robert Kennedy chaired the interdepartmental Special Group on Counterinsurgency.

Thereafter AGILE declined and its White House "line" withered. A substantial number of projects were added to the Vietnam Combat Development and Test Center, most of them a matter of testing or modifying various kinds of off-the-shelf equipment. In both Vietnam and Thailand ARPA arranged for the first anthropometric surveys ever conducted for the military services of the two countries, and developed their first field rations using indigenous food. This work had its light moments. The "military requirement" for field rations was little more than recognition that Vietnamese combat units were jumping out of aircraft into battle with live pigs and chickens under their arms because there was no supply system. ARPA spent months seeking a container that could hold "nuc mom" and "nam pla," the fermented fish sauces that are staples in Vietnam and Thai diets (and were purported to eat through tin cans).

It was an article of faith in Godel's concept of AGILE that ARPA also seek to create an indigenous R&D capability within the countries where ARPA was operating. It was an enlightened idea, but a stupendous undertaking because most developing countries have few trained people and little research tradition, especially in the military. Nevertheless ARPA tried hard to make the Joint Vietnamese-U.S. and Thai-U.S. CDTC's* as "joint" as possible. Quite naturally, the host nations were more interested in receiving equipment that their armed forces could use than in running experiments. This conflict in priorities was never fully resolved.**

ARPA continued to find it immensely difficult to run a far-flung field empire. It was a great burden on the small headquarters staff, which had little relevant experience of this type. Washington never fully understood the trials and tribulations encountered by its field unit personnel in trying to introduce and create something as novel as "R&D capabilities," while also producing sophisticated research results, in cultural and bureaucratic settings that were equally as novel in their own right. The field staff, moreover, rarely succeeded in communicating its frustrations accurately to Washington. The constant harassment of both by CINCPAC and the on-the-scene U.S. military exacerbated this situation. Pressures to achieve R&D successes, in part to quiet down critics, never stopped. T. W. Brundage, first director of the Thailand unit, reflecting on both the substantive problems of dealing

* The title of the Thailand organization was subsequently changed to Military Research and Development Center (MRDC).

** The British and Australian governments assigned a handful of technically-oriented officers to the CDTC's as well. They tended to participate in projects that matched their training. The British also sent several air cushion or Surface Effects Vehicles (SEV) for testing by the CDTC's. They were deemed to be complete failures.

with counterinsurgency and the associated organization and management difficulties, says that one must accept a truly long term perspective -- 50 years -- to make such an effort worthwhile. "If you're not prepared to accept that, there is not much point in starting it."[67] Bitter arguments among senior staff at both ends of ARPA's half-a-world-away pipeline were not unusual. There never was time to focus on the process of establishing and managing a worldwide enterprise. It is regrettable that no attempt was made subsequently to evaluate this experience for "lessons learned" purposes.

During the Sproull years AGILE tried to get away from "gadgeteering" and to introduce "real science" into the work. The basic idea was to observe and analyze scientifically the environments within which insurgencies were being fought. Somewhat similar to DEFENDER, "measurements" became the focal point of ARPA activity. By measuring and recording the basic physical characteristics of vegetation, soils, weather, etc. one could then begin to design techniques and equipment to function under such conditions. In some instances, it was hoped, local materials could be used. This environmental approach was a cardinal point in Godel's conception of AGILE and Sproull found it much more attractive, professionally, than field test and modification of on-the-shelf pieces of equipment. The most likely long term flow of events in such a program, however, would be field investigations, preliminary analysis of data in the field and/or in the U.S., more sophisticated data analysis and development of prototype equipment in the U.S., test in the field, manufacture in the U.S., and finally delivery of end items in quantity, presumably via the Military Assistance Program (MAP). This flow was never clearly spelled out and few indeed appreciated its complexity. By and large it proved to be unattainable.

In some respects Sproull seems to have fastened on the AGILE environmental work as a plausible segment of activity in an otherwise hostile situation. By mid-1964 he had become quite disillusioned by U.S. policy in the Vietnam War. He recalls, for instance, leaving a meeting in the CINCPAC War Room "terribly depressed" because the principals were obsessed with daily indicator reports and trivia and never talked about anything that "made any real difference."[68] Concluding that "the whole thing [the war] was a disaster," Sproull decided that the only thing for ARPA to do was concentrate on "what we can get out of it," i.e., learn from it, because "we weren't going to have any influence on it."[69]

The Godel Departure. In late 1964, W. H. Godel, who by that time had been elevated to the position of ARPA Deputy Director for Management and who remained the primary force behind the AGILE program, was indicted along with two other senior OSD officials on charges of embezzling government funds. This incident was to be the sole personnel "scandal" in ARPA's history and was at the time a severe blow to the Agency in general and to the AGILE program in particular. The episode was long remembered and constituted a source of allegedly recurring embarrassment for ARPA for some years to come.*

The Godel case was a source of considerable controversy within and outside of ARPA. AGILE's management of funds and projects in Vietnam was already a source of dispute quite independent of Godel's problems, and ARPA was strongly criticized in a contemporary OSD audit for "non-compliance with regulations and standard procedures" and inadequate accountability records, which in turn were attributed in part to a "need to get the job done" attitude.[70] Godel was, of course, a primary advocate of ARPA's quick-reaction role in Vietnam, which did entail rather complex and loosely controlled dealings with local officials. The extent to which his personal legal problems were related to an effort to fulfill ARPA's quick-reaction Vietnam missions in a loose administrative environment is not clear. Godel, who of course left ARPA after the indictment, had both loyal supporters and strong critics in this regard.

The subsequent impact of the Godel conviction on ARPA had little to do with the specific contents of the case, but rather concerned the legacy of suspicion it produced concerning ARPA programs, particularly AGILE. Dr. Herzfeld, who became a strong supporter of AGILE largely through Godel's exposition of the program, states that the incident left AGILE with the image of an operation that "had some shady overtones -- and things that best not be looked at too closely."[71] This kind of suspicion, Herzfeld continued, was very "corrosive" since it could never really be countered: "the better the stories then sound, the more suspicious people tend to get."[72] It became harder to get money for the AGILE program.

* The details of the indictment and subsequent events were not reviewed thoroughly and are not important to the ARPA story. In very summary form, a federal grand jury brought a 43-count indictment against the three civil servants, one specific charge against Godel relating to a purportedly false voucher for $10,000 "for certain confidential projects in Vietnam." Godel was permitted, following these charges, to go to Vietnam in February 1965 to seek evidence in his defense. He was tried in May (along with one of the other defendants, one case being separated) and was found innocent of two embezzlement charges, but convicted of one conspiracy to embezzle charge and of making a false statement regarding the expenditure of funds on the Vietnam project. The other individual was convicted on three embezzlement and two false statement charges. The jury evidently had some difficulty in weighing the Godel case, as it was out for more than twenty-five hours over a three day period.

In later years, the initial obscurity of the episode and large ARPA personnel turnover combined to make memories of Godel's departure circumstances extremely vague. The event nonetheless continued to have a pernicious effect on ARPA's reputation; at least both Drs. Rechtin (1967-1970) and Lukasik (1971-1975) recall incidents in which the "legacy" of misdeeds of a high ARPA official were thrown in their faces in dealing with other Defense and Service representatives. Lukasik, in particular, cites the distorted accusation, "Oh yes, didn't one of your Directors go to jail?",[73] being used on several occasions. The incident also affected the AGILE program itself as late as Rechtin's encumbancy. He recalls AGILE's general image when he became Director, as follows:[74]

> AGILE had given ARPA a bad name, unfortunately because they went through some techniques that were excessive. And because there was hanky-panky in the funding. I am not sure just what all the motivations were, and don't care. The point was that it was not done in a good, clean, straightforward fashion.... So that lasted and gave ARPA a black eye. And it was not good.

Thus, whatever Godel's contributions to ARPA -- and there were many -- his personal downfall became a cloud over ARPA's reputation in the turbulent decade to follow.

SEACORE. One of the larger AGILE programs in the Sproull period was a Thailand-based project known as SEACORE (for Southeast Asia Communications Research). The project was initiated late in the Ruina period (July 1962), but was developed during Dr. Sproull's tenure and continued in Herzfeld's. It reflects the emphasis of the Sproull period on infusing AGILE with more fundamental, longer-term projects with a sound base in measurements. SEACORE, conducted in conjunction with the U.S. Army Signal Corps was concerned with measuring radio propagation (path loss) in jungle terrain, delineating current military communications techniques in Thailand in relation to this background data, and testing some new communications equipment and technology which might be better fitted to local radio propagation conditions. A core idea was to measure attentuation carefully and plug that knowledge into a suitable theory of transmission. There was some recognition of the frequencies that might work and that it was possible to transmit along the tops of the trees as well as along the ground. Initially conceived as an 18 month, $2.5 million study, the program continued into 1968 with a total cost of approximately $14 million, even though the effort came to be regarded as a considerable disappointment before Sproull left ARPA -- one of the relatively few obvious non-successes of his period.

The decision to initiate the SEACORE program appears to have been driven by a desire to strengthen the technical basis of the Thailand field unit's work effort and to move away from quick-reaction assignments. It was also deemed advisable to consolidate jungle communications research in an area closer (and presumably more similar) to Vietnam, where the primary tropical warfare problem existed. The SEACORE project itself was, in a sense, not new, because the Signal Corps had been supporting similar research in Panama since 1961. SEACORE redirected the Signal Corp's Panama contractor to Thailand and added additional research moneys. ARPA funds were substituted for Army support, but the Signal Corps was retained as the contracting agent.

By 1964 the research on radio propagation had come to focus on a number of basic studies of terrain characteristics, vegetation in jungle environments and weather conditions, and paralleled a number of other Thailand-based efforts focussing on environmental conditions (e.g., Mobility Environmental Research Study, defoliation studies and a major vegetation study covering much of Thailand). In January 1964, the program was reviewed by an ARPA consultant who concluded that the SEACORE work was not being conducted successfully and had little potential due to inadequate contractor problem definition and approach. Rather than terminate the research, however, numerous efforts were made to reorient the program through contract extensions and amendments. Research dragged on -- largely oriented toward additional data collection in various environments -- into 1968. In retrospect, one of the biggest errors in program concept and management was underestimating the difficulty of achieving proper analysis of the data, once it was collected. No equivalent of the Lincoln Laboratories in PRESS emerged to perform that function.

The other half of the program, examining Thai military communications techniques and various technical improvements which might be made, encountered equal or greater problems. By late 1964 these (largely operations research) tasks were also in trouble, and there were contractor recriminations concerning ARPA management, field conditions and related problems. Consequently, ARPA requested the contractor to terminate the operations research effort and draft a final report, which was very poorly received in terms of technical quality. Despite the negative assessment in the Sproull period, this part of the SEACORE effort also hobbled along through many modifications and amendments into 1968. The basic problem apparently was lack of genuine user enthusiasm for the communications research effort, either from the Thai or U.S. military, while at the same time commitments to the Signal Corps, the Thai MRDC and the contractors proved difficult to shed. These problems in turn were partially due to lack of specific user requirements, difficulties in managing a remote field effort and ARPA's heavy reliance on Signal Corps and interested contractor personnel in monitoring the effort. As Sproull later noted, finding quality contractors for field research on environmental factors was very difficult: hence in contrast to much other ARPA work, long-standing Service contractors were used, with the potential disadvantage that their views often paralleled relatively fixed Service views.[75]

In short, although the Sproull period's emphasis on orienting AGILE's research toward longer-term, fundamental issues may have been quite sound conceptually, the SEACORE program indicates that it was most difficult to accomplish in fact. While SEACORE may have had some marginal achievements, e.g., leaving some enhanced Thai military communications research capability, it appears to have neither substantially affected Thai military communications capabilities nor to have made a major contribution to the state of the art of communications in a jungle environment.*

Mobility Environmental Research Study (MERS). MERS was a very large scale effort paralleling the SEACORE work. Space limitations preclude lengthy discussion, but it is important to note that a combination of measurements work and vehicle testing (including some exotic propulsion and traction concepts) failed to produce much. The theory behind it was classic ARPA/AGILE: The U.S. military had tended to design and buy vehicles suited for the plains of Europe and highway use. A new theory of ground mobility was needed for tropical areas. Unfortunately, nobody had one. Ignoring that, contractors jumped into measurements work. As Brundage noted, you could not get anybody to define a way of measuring mobility and "without a proposition to test, you probably shouldn't charge ahead."[76] Nonetheless, ARPA did, in its zeal to attract first rate scientists to this new "unknown" and to make a potentially great contribution to tropical warfare. Regrettably, the scientific community did not produce high quality people or answers. ARPA could not repeat its space, BMD and VELA success stories in this regard. As in communications, ARPA was left with traditional Army groups and their contractors and what amounted to a data gathering exercise. The Army, of course, lobbied hard for the job, in part to protect its own interests. Since industry offered no alternative, ARPA had nowhere else to go. Godel says that he and Brundage thought that they could control the Army participants. This, he notes, was "bad theory."[77] Brundage, viewing this program somewhat wistfully in retrospect, gives a reasonably accurate summation of MERS:

* Drs. Herzfeld and Rechtin, believe, however, that some measurements taken by the Jansky and Bailey Corporation were of great value and ultimately came to influence the U.S. military to the extent that today U.S. tropical communications capabilities have been upgraded. (Discussions with Dr. C. M. Herzfeld, July 2, 1975 and E. Rechtin, July 7, 1975.)

"I can't prove it, but I think it was all a fiasco."[78] Herzfeld is gentler:[79]

> I think the mobility may have suffered from being in advance of the state of the science -- of the engineering subject -- that goes with mobility, and I am quite convinced that the empirical data taken were very useful. I think it did not jell from a analysis and theory point of view, and it did not succeed in overcoming the inherent conservatism of the professionals in that field. I think it was worth trying. I don't think there was anything wrong with that.

A prudent observer might say that ARPA was unusally tolerant in allowing latitude for Herzfeld's abstraction to try to work itself out in practice.*

Dr. Rechtin came to ARPA after the environmental effort had been subordinated by "systems" interests and the immediate demands of the U.S. military in Vietnam. Against that background, the environmental work seemed to show up relatively well, although he did not consider it particularly relevant to counterinsurgency:[80]

> I thought the environmental work was good. Whether or not ARPA should have done it, or the Army should have done it, or somebody else should have done it -- damned if I know. But it was interesting, well done work, and worth the money. It was a proper sort of thing, if we are going to fight in jungles, to know much more about it. So that was ok. It had nothing to do with insurgency as such. That was straight tactical Army.

Today, Sproull believes that the U.S. military still would benefit from a program of environmental research for use in preparing themselves for

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* As an aside on ARPA's mobility research, quite apart from the program above, the Agency also investigated various advanced vehicle concepts including work on a project variously known as a "mechanical elephant" or "mechanical horse" which was to move through servo-mechanism "legs". When Dr. Rechtin came across this effort after becoming Director, he was appalled. Seeing it as a "damn fool" project bound to stir up Congressional ire if it ever publically surfaced, Rechtin quickly cancelled the effort.

emergency situations. In any event, ARPA won few comments:[81]

> [O]ur military did not take it on as much as we thought. There is no question in my mind that when we were thinking AGILE in a big way -- somewhere through '65, '66, '67 -- that some of us had a vision of really changing, radically, the amount of information about local conditions that would be available and that would be used. And neither of that happened, except sporadically.

<u>The Soft Side of AGILE</u>. Despite its hardware and "hard science" image, ARPA's AGILE leadership -- very much reflecting Godel's sensitivity to the "people" aspects of insurgent warfare -- began to undertake studies in Thailand intended to focus on the village and rural atmosphere within which insurgent situations seemed to develop. Despite the sizeable American military presence in Thailand, it was the MRDC that undertook the first village survey designed to shed some light on what, in fact, Thai rural villages looked like. Despite the massive rural area problems being encountered in South Vietnam, the American and Thai military seemed almost to take a "it can't happen here attitude." They were fixated on the hypothetical threat of large scale invasion by the Chinese. The MRDC effort, a relatively crude first cut exercise, involved sending a Thai-U.S. team composed of an economist, engineer, forester, anthropologist, and operations analyst to 40 villages in Northeast Thailand. Their report covered physical characteristics, locational and communications data, population and census information, officials and village leadership, villager skills and specialists, migration patterns, and villager responses to perceived "threats." As of early 1964, the primary threat proved to be cattle and buffalo rustling and it was revealed that villagers were rather imaginative in organizing themselves to deal with it.

ARPA was able to do such work in part because the Joint U.S. Military Advisory Group (JUSMAG) had little interest in it and because the American Ambassador, Graham Martin, supported it. Martin had been particularly impressed by ARPA evaluations in 1963 and 1964 of the only counterinsurgency action program then actually in operation, the Thai Mobile Development Unit (MDU) program. Originated by the Thai, this program was looked on by both JUSMAG and the AID Mission with some suspicion. Martin eventually insisted on U.S. support for it from both of them, relying in substantial measure on the ARPA reports. The latter were based on extensive observation of MDU units in the field. Several years later a similar comprehensive analysis of the Thai Mobile Information Team program was done under ARPA auspices.

The Thailand group's interest in focussing on the practical problems of dealing with rural insurgency by means of attempts at actual observation was carefully nurtured by Brundage and the results were generally well received in Washington. Sproull, in particular, felt comfortable with what he thought was a unique and sensible approach to a problem that somehow was not showing much sign of yielding to brute force application of gadgets, scientific formulae, and money.[82]

Throughout much of ARPA's involvement in Vietnam, the Rand Corporation and occasionally others were commissioned to do evaluations of programs such as Chieu Hoi (Viet Cong defector rehabilitation), refugee resettlement, Strategic Hamlets, and the role of the American advisor. ARPA funded RAND's controversial series of interviews with VC prisoners and defectors, the results of which achieved "best seller" status for a time within government. Secretary McNamara read these reports avidly and met occasionally with the principal investigator. At a time when the U.S. military threatened to force cancellation of this work, ARPA worked hard to obtain co-sponsorship by the Assistant Secretary of Defense for International Security Affairs and expressions of interest from other agencies and departments. The need for such bureaucratic antics itself illustrates the fragility of ARPA's AGILE assignment.

As much or more than any other agency in Washington, ARPA became a spokesman for considering the significance of the "people" factor and emphasizing that, like it or not, U.S. policy and programs were ignoring it. In that sense, it was frequently a purveyor of bad news and that did not help the AGILE cause in and around the Secretary's office. Later in the 1960's AGILE itself was to distort and misinterpret the social and behavioral characteristics of the problem in a gross attempt at solving the insurgency problem by means of a completely comprehensive "systems" design.

Advanced Sensors

The one new program office established in ARPA during Dr. Sproull's tenure involved research on "advanced sensors." The office was created toward the end of the period and began with a FY 1966 budget request of $4.8 million. The office grew steadily after Sproull's departure with some $6.6 million of FY 1966 funds actually spent during the first year of the effort, and the budget request growing to $10 million in FY 1967 (the first Herzfeld budget). Growth continued into the late 1960's with budget requests peaking at about $30 million. The office was to have a stormy career, complicated by Vietnam-oriented projects that came under strong criticism, and was ultimately disestablished by Dr. Lukasik in the early 1970's.

As may be readily inferred from the program title, the new office was directed toward developments in sensor technology of interest in military intelligence (and counterintelligence) settings. Sproull says that there were three principal reasons for entering this field: (1) a feeling that the Agency ought to get into new things, partly to boost morale and partly because an advanced research agency ought to show some motion, (2) the fact that VELA had become involved in diagnostics and developed close relations with the intelligence community, thus setting a precedent, and (3) a conviction that ARPA had a unique contribution to make via its contacts with the best technical people, a qualification that intelligence agencies could not match.[83] In addition Sproull recalls that there were some "local aficionados" promoting the idea, namely, Herzfeld and Godel. Herzfeld says that the two of them conceived of the program in 1963 and eventually sold it to Dr. Fubini in ODDR&E. Its purpose was, at least in part, to do R&D on:[84]

> ... protecting U.S. assets from intrusion by other intelligence operations. The reason for that is that there is very little of that being done. Everybody works on the positive side. People don't like to work on the defensive side of that problem.

Because of its relationship to the intelligence community, the program was quite sensitive from the beginning and was described in unclassified form only in broad and vague terms. The following is illustrative:[85]

> Studies will be undertaken in basic optical technology including lens design techniques, new materials, and new methods of manufacture. Novel systems for studying the effect of the atmosphere on the propagation of coherent and normal light will be investigated.

Because of the office's generally sensitive institutional relationships, specific programs are not described in depth in this or subsequent chapters. It is sufficient to note here that military intelligence techniques were as greatly affected by the technological revolution of the late 1950's and early 1960's as other operational components of the DOD. The realm of sensor devices involved highly sophisticated technologies that appeared to offer natural subjects for an advanced research agency. In addition, Defense intelligence problems were, of course, frequently multi-Service in nature so that an ARPA role was a plausible development on this criterion as well. Moreover, radar, optical and other developments within the DEFENDER and VELA programs frequently had implications for strategic intelligence, e.g., techniques used to discriminate among reentry vehicles might be applicable to intelligence monitoring of reentry vehicle tests. It could be argued that AGILE's mission implied tactical intelligence requirements. Hence there was a relevant background of technical and mission interests in ARPA which could contribute to the establishment of the Advanced Sensors office. As noted the office was established only toward the end of the Sproull period and its development will be summarized further in later chapters.

Over the years ARPA has become increasingly frank in discussing the intelligence applications of its technology development programs. On the strategic level, for example, space surveillance work has been publicly discussed, as have various tactical surveillance and reconnaissance efforts. In addition, behavioral sciences work relating to improvement in intelligence analysis procedures has frequently been cited in an unclassified form. In FY 1973 testimony Dr. Lukasik noted that the Advanced Sensors program was reducing its quick-reaction Vietnam efforts and was "returning to its original goal of exploring fundamental sensor technology for a wide range of intelligence and tactical surveillance problems."[86] This is a fair statement of the program's purpose, without the kind of pussyfooting around the term "intelligence" that sometimes occurred in earlier years.

Materials Sciences

As in a number of other ARPA program areas, the Materials Sciences program was a going concern when Sproull arrived. The difficult process of IDL selection was now past and a number of achievements were on the record. The July 1964 ARPA Annual Report, for example, could point to over one thousand scientists -- faculty and past-doctoral research associates -- at work in the materials laboratories; an increase in materials-related Ph.D's produced by the IDL's from 178 in 1960 to 280 in 1964; and new research ranging from semiconductor materials and the effects of high pressure on materials to laser components and high strength composites.[87] The related crystal growth program also showed some significant accomplishments.

Nonetheless, reminiscent of Ruina's attitude toward DEFENDER when he became ARPA Director, Sproull cast a critical eye on Materials Sciences, the program that he knew most about:[88]

> I did think that the Materials thing was going badly because [the Materials office head] was attempting to ruin it by a much too narrow an attitude toward things and by not pushing the engineering part of it enough.

Sproull did not want ARPA to become a "materials agency" and he definitely did not want to expand the IDL's. He hoped that the IDL's would make a special contribution in linking science with technology but they were proving to be weak in their role.[89]

Despite his university background and previous position as head of the Cornell IDL, Sproull also was not content to continue to treat the DOD's interest in supporting a university basic research program in materials as self-evident. The 1964 Annual Report leads off its description of the materials program, for example, in a manner quite different from comparable statements in earlier years:[90]

> Changing strategic concepts, advances in weapons systems technology and a greater variety of environmental conditions under which military hardware must operate effectively have created increasing demands for developments resulting from materials research and technology. Improvements in materials are a basic requirement in achieving new items of military hardware or in the improvement of existing hardware.

Not only did the effort to provide a military rationale for the IDL program become more explicit in the Sproull period, reflected in his speeches as well as general program statements, but numerous steps were taken to increase the focus of sponsored research on DOD problems. For example:[91]

> In order to focus the attention of the IDL universities on DOD applied materials needs, ARPA, during the past year, has arranged for increased communication between the IDL participants and their counterparts in DOD laboratories. This has been accomplished by selecting competent researchers in DOD laboratories to devote time in the laboratories of the IDL universities. Also, ARPA initiated sponsorship of meetings at DOD laboratories which are designed to expose IDL participants to the most urgent DOD materials problems.

The major Sproull initiative toward increasing the military relevance of the materials office and building up the linkages between science and technology that he sought, was the institution of a major new program which came to be known as the "coupling program" Begun in the latter part of FY 1964, this program was designed to support joint (or "coupled") university and industry-defense laboratory programs oriented around specific defense-related materials problems. The concept was to bring basic research talents from the university environment to bear on applied research problems in a more direct and substantial way than was typical, with the resultant combination of talents expected to contribute both to a better solution to the specific applied problems addressed and to an improved appreciation in the universities of applied research needs and requirements. Indeed Sproull hoped "to convince the better graduate students at universities that technological problems [could] be equally as exciting as scientific problems, and that even a first-rate scientific graduate might find a more productive career in applied science or engineering than he could find in pure science." [92] By the same token he felt that if companies were to perform successfully for DOD and survive commercially, they ought to have first rate expertise in materials and therefore would benefit from participating with university researchers in advancing materials technologies. Sproull's philosophy for the Cornell IDL that he established had been "to stand on the shoulders of science and reach toward engineering."[93] There was much the same flavor in his approach to coupling. He stipulated that the teams working in this program "must be responsive to Defense Department needs" and DOD priorities were to be maintained as part of the program design.[94] Since it was an applied program, Service agents were to be used in order to provide maximum exposure and participation for them, i.e., provision for a transfer mechanism. Sproull was personally very interested in this program and in fact participated in drafting the program plan.[95] Three major "coupling" contracts were established under this new program element. They became a substantial component of the materials program that carried into the Herzfeld period and are addressed further in that discussion.

In addition to Dr. Sproull's personal interest in a more applied program, it appears likely that the gradual shift in the Materials office's orientation was also partially in response to DOD pressures for a more relevant program. At least as early as late 1963, just after Sproull became Director, there were suggestions that the IDL program might be transferred out of the DOD (NSF being the logical candidate) or that the program should become more applied and directly oriented toward Service projects. In the early sixties these tendencies to question the kind of institutional funding represented by the IDL's were successfully countered, but it was necessary for the Materials staff to mount a vigorous defense:[96]

> In answering the question [of] should the IDL's be kept in ARPA, the following factors (the basis for establishment of the IDL's and the result of numerous committee fundings) are accepted as true:
>
> 1. the need for fundamental research is increasing;
> 2. the ready store of fundamental research is decreasing;
> 3. military device development is vitally dependent upon fundamental research;

4. lack of fundamental research threatens future development of new and improved weapons;
5. increased research, and the compression of the time between research findings and the weapons system is mandatory to prevent this country from being vulnerable to technological surprises;
6. increased efforts should be made toward utilizing available fundamental research information in military development programs....

No other existing agency considered for possible transfer comes to have the built in sense of urgency, need, knowledge or organization to properly execute this overall program as well as the Department of Defense. The National Science Foundation is education and discipline oriented and does not appear to have adequate communication lines into and out of the military services to effectively and quickly utilize the research information generated. The AEC is, by charter, nuclear oriented and would not have necessary knowledge of the overall needs of weapons systems. NASA is, by charter, oriented toward peaceful space development and again does not have the necessary knowledge of weapons systems needs. None have built in organizational ties with the three Military Services, as does ARPA. As all of these agencies are outside the Department of Defense, DOD would not have any control or voice whatsoever in the management of the IDL's if transferred. Even a decision to discontinue would be outside of DOD jurisdiction.

In summary, the Materials office in Sproull's years continued on course but added a more explicit military rational and applied research focus. One cannot measure the extent to which this gradual shift derived from Dr. Sproull's personal interest or was a response to criticism within DOD of the appropriateness of ARPA's predominant role in supporting university basic research (which was always present). Probably both factors were important.

Forward Funding. The forward funding (also called longevity funding) arrangements of the IDL program, and to a lesser extent of other ARPA university programs, were to come under considerable internal attack within ARPA and DDR&E in the late 1960's. Both Dr. Rechtin and Dr. Foster were outspoken critics of the concept, feeling that three years advance funding was completely unjustifiable.

In the Ruina-Sproull period there was also significant internal DOD and ARPA opposition to forward funding, but DOD-university relations were benign and the positive arguments carried the day. In view of the later debate over this issue it is useful to review the rationale given for the arrangement. First, it was felt that the magnitude of the university commitment -- in terms of curricula development, hiring of tenured faculty, commitment of facilities and equipment, etc. -- made it reasonable for universities to seek the certainty provided by multi-year advance funding. Universities were distinguished from industry in this regard by several factors, e.g., the longer term staff commitments entailed in tenure and the very broad side effects of a laboratory on the university's primary instructional role. Second, it was felt, well into the Sproull period, that the university infrastructure in materials science (and other fields) was weak and that this weakness in technical areas of interest to the Defense Department was itself a matter for legitimate governmental concern; thus to the extent that guaranteed advance funding provided stability to this infrastructure, it was an acceptable administrative device. Third, forward funding was regarded as a lever with which to attain counterbalancing advanced commitments from the universities. According to D. K. Hess, Sproull was quite insistent that ARPA would normally pay only about a third of a faculty member's salary, which meant that the university would be obligated to make substantial continuing outlays.[97] Sproull often made the point that ARPA was in fact the minority partner in supporting the IDL's, when university internal funding and outside project support was taken into account. He was insistent that the universities not rely primarily on ARPA funds. Since expanded teaching and research programs were regarded as important to Defense in their own right, the output of the non-ARPA investments were weighed against the tie-down of money in advanced funding used as a "carrot" to secure these investments, and the balance was judged to be in favor of the forward funding approach. Throughout it was assumed that universities would not expand their basic research capabilities without long-term guarantees and that DOD would suffer without such expansion. These were critical assumptions and before the 1960's had ended they became subject to considerable derision.

Information Processing Technology

In the information processing field, as in many other program areas, Dr. Sproull's ARPA appeared to reap the harvest of policy decisions and investments made by earlier Directors. In this instance almost all of the fundamental decisions regarding program direction appear to have been made during the Ruina period: to reorient the program away from more narrowly conceived command and control problems to a broad attack on advanced computer technology, to shift priorities from reliance on SDC to support of academic centers of excellence across the country, to underwrite research in time-sharing in a major way, etc. Just as PRESS first began to generate voluminous reentry data and the IDL's began to produce increased numbers of students, projects and theses, the impact of Dr. Licklider's efforts in information processing was first felt during the Sproull period.

The centerpiece of the information processing program was clearly project MAC at MIT. During the spring of 1963 work began to go forward as the details of contract scope and funding moved toward resolution. By the time Sproull arrived in the fall, MAC was a going concern, a solid three million dollar program supporting a broad effort in development of software, computer languages, computer graphics techniques, and related work. As in the materials field, the numbers of faculty and students supported in advanced research areas by ARPA funds came to be regarded as major accomplishments.

If, however, MAC was the centerpiece of the information processing program, the centerpiece of MAC was its work in time-sharing, specifically the development of the first sizeable time-sharing system capable of serving dozens of simultaneous users. Known as the Compatable Time-Sharing System (or CTSS), the MAC system, using a modified IBM 7094 computer, was not just an experimental prototype, but an operating system serving the MIT research community. Though limited time-sharing systems had been developed earlier (e.g., at Bolt, Beranek and Newman) the scope of the MIT system, made possible through ARPA funding, was far greater than anything produced to that date, and equally important, was supported in depth by a broad MAC research effort in languages and software. By the middle of Sproull's tenure, CTSS was becoming recognized as the leading development in time-sharing and MIT the leading institution in advanced computer research. Project MAC had become a mecca for American and foreign scientists in the field. CTSS was thus highly visible and had a far-reaching effect throughout the computer industry. In Dr. Licklider's words, the pre-ARPA work in time-sharing:[98]

> ... was just not critical. What there was at MIT was either a two-terminal or three-terminal one time-sharing system; at BBN it was either a three or four-terminal one. The one at BBN ... was so weak and impotent that people used it alone rather than in the time-sharing mode ... the one at MIT was just a ponderous clunker ... I don't know when time-sharing would have been if it wasn't for ARPA.

By 1964 the rapid CTSS development had proven such a success that the decision had been made to move beyond that system to an even more powerful time-sharing arrangement capable of serving hundreds of simultaneous users. During the year the major contract to supply computing equipment for this "second-generation" time-sharing system (eventually known as the MULTICS system) went out for bids. To the surprise of many in the field, the industry leader, IBM (which had supplied the equipment for CTSS) failed to receive the award. The winner was General Electric, who quickly found two other customers for similar time-sharing equipment. Meanwhile, MIT's Lincoln Laboratory had become convinced of the utility of time-sharing, went out to bid for a system and selected IBM.

The ARPA view of its influence on these developments is reflected in the following excerpt from a memorandum Licklider's successor as Director of IPT, Dr. Ivan Sutherland, sent to Sproull:[99]

> In connection with Lincoln's recent choice of IBM equipment, there has been some criticism of the previous Project MAC decision for G.E.'s computer. The ideas for time-sharing and input-output contained in the IBM proposal to Lincoln are clearly the result of several year's planning at IBM. It is not clear, however, that before the Project MAC decision these advanced ideas were considered important by the IBM management. It is clear that, since last Summer, the time-sharing equipment picture has already changed considerably. I stated in a previous memorandum that the Project MAC decision against IBM would spur all parties involved on to greater productive efforts. I believe that Lincoln's choice of IBM equipment for a time-shared system is probably an indication of the effectiveness of this competition and will, itself, serve as an additional spur for technical productivity.

The view that ARPA gave much needed impetus to the time-sharing field, including IBM, is not restricted to ARPA personnel, but is widely held. During the early 1960's there was a greatly expanding market for conventional computers and industry was understandably conservative regarding an unproven advanced concept. In the view of one observer, ARPA was necessary "to get time-sharing to happen" and it took five or six years to get industry firmly behind the developments.[100] By the late 1960's and early 1970's, however, time-sharing had become a major segment of the computer industry.

The time-sharing example is only the most prominant of the accomplishments beginning to derive from the IPT program during the Sproull period. There was also important developments in computer graphics, a major example being the so-called "RAND Tablet" which provided a direct and convenient means of providing graphic input to a computer and stimulated many subsequent developments. Research in advanced programming techniques and languages (LISP, ALGOL, etc.) at MIT and elsewhere have had a lasting effect on the state of the art. Major research was also supported in computer display techniques, computer architecture and related areas. Centers of excellence in the field of " artificial intelligence" were established which have had considerable influence in areas going far beyond the worlds of "robots" and chess playing programs popularly associated with the field; especially in very advanced programming concepts.

Thus Dr. Sproull saw the first fruits of ARPA's decision to inject major funding into advanced information processing. Somewhat similar to the situation in materials science, the academic community had been in an inferior position to industry because of the cost of facilities and equipment needed to support advanced research. ARPA funding at a critical time contributed greatly to rectifying this situation, and -- even more than in the case of materials science -- some rather dramatic breakthroughs quickly resulted. ARPA attained a reputation as the dominant supporter of truly advanced information processing research worldwide, which to a considerable extent it was to keep into the 1970's.

Behavioral Science

The ARPA Behavioral Sciences program was initiated late in Dr. Ruina's tenure with an assignment (called Project CARINA) from the DDR&E to "undertake research in the behavioral sciences ... in support of the requirement of the Department of Defense for increased understanding of human behavior."[101] Some $1.8 million in FY 1963 and $1.6 million FY 1964 was allotted to initiate this broad assignment, which actually began to develop projects only with Dr. Sproull's arrival as ARPA Director.

As noted earlier the assignment followed a Defense Science Board (DSB) recommendation derived from conclusions of a report produced by a Research Group in Psychology and the Social Sciences of the Smithsonian Institution, generally referred to as the Smithsonian Report.[102] It appears that ARPA had little or nothing to do with obtaining this assignment. Ruina simply recalls receiving it and having the problem of finding someone to direct the program. His choice was Licklider, whose excellent work in psychoacoustics and professional contacts in psychology and related fields were aptly suited to the task.

During the Sproull period, the behavioral science program appears to have been rather diffuse, with a number of separate efforts funded in the $100,000-$200,000 range, substantial support compared to what had been traditional in this field, but small compared to projects in most of the other ARPA offices. The program was clearly university-oriented and considerable effort was placed on seeking out capable senior or clearly outstanding social scientists around which projects could be developed. Not surprisingly, as noted in the Ruina section, Licklider placed emphasis on computer-related social science. This was also consistent with several Smithsonian Report recommendations. Computer-aided teaching systems* and computer assisted gaming and simulation studies are examples of work chosen. On the basis of personal interest and a feeling that "human performance" research was bound to be Defense relevant, Licklider supported groups of psychologists at Michigan and Ohio State, for instance, in hopes that Human Performance "centers of excellence" might emerge. They did not and Licklider subsequently concluded that "centers" never would work in the social sciences because most social scientists want to work alone or be in charge of their own group, i.e., the "great men" will not work for one another.[103]

When Licklider left in 1964, Sproull selected Dr. L. W. Huff, a career civil service man then serving as de facto deputy of the Thailand field unit. Sproull wanted to build a bridge from psychology into the other social sciences. Huff, who was trained in economics and political science and was accustomed to working with anthropologists, sociologists and social psychologists, was given that assignment. Behavioral Sciences and IPT were divided into separate offices and Dr. W. Cody Wilson, a Harvard-trained psychologist, was recruited as Huff's deputy. This action doubled the size of the office's professional staff and a third member (Professor Raymond Tanter, a quantitative political scientist at the University of Michigan) was authorized just after Sproull's departure. These expansion plans illustrate the willingness of both Sproull and Herzfeld to carry out a quality program in a controversial area.

A new program element addressed to the interdisciplinary study of social processes was introduced and a segment of that work emphasized basic research on the developing countries. This put the office and ARPA squarely in the midst of "foreign area research" issue that was to become so inflammatory in the late 1960's. With the addition of this new assignment, the ARPA Behavioral Science budget was expanded to $3.9 million in FY 1966, the beginning of Dr. Herzfeld's tenure.

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* ARPA made a significant contribution here, notably to the development of the PLATO instructional system. Interestingly, work in this area declined over the years, and when a new initiative in the field was taken in the 1970's (a test and evaluation of computerized instruction techniques as part of a joint program with the Services) PLATO was selected as the most appropriate system available, one of the ARPA program managers being unaware that his office had sponsored its early development. This is one of numerous examples which could be cited to illustrate the gaps in ARPA's institutional memory.

There was a decided "Defense relevance" cast to the reason why ARPA undertook this work. ARPA became convinced that knowledge of other societies was essential, especially during a period when it was U.S. policy to intervene in them constantly. More often than not the White House and/or State Department, upon deciding to intervene, then proceeded to select DOD as the intervenor; that is, it was DOD personnel who were "sent in."* Most of the time DOD was poorly prepared to deal with the changing environments in which it was placed. On the other hand, the State Department felt no obligation to do the research necessary to improve DOD abilities to perform; indeed, the State Department had an anti-research bias that bordered on the extreme, so it clearly would never undertake the research. DOD/ARPA, as in so many other areas, stepped in to try to fill a perceived gap, initially by attempting to support basic research by quality university researchers on the process of change in developing countries. The near-term objective was to determine whether anything useful could be produced, i.e., did the social scientists have anything to offer?

While the office continued to support considerable work which was unrelated to foreign area research and socio-political conflicts in developing areas, these latter subjects came increasingly to dominate the "image" of the office. By the time of Dr. Herzfeld's arrival, the Behavioral Sciences programs were to be frequently confused with AGILE programs (AGILE had added a variety of applied behavioral science projects directly related to insurgency). In an era of considerable concern over the legitimacy of Defense research on insurgency, this confusion caused the office considerable problems.

In the Sproull period, however, the behavioral sciences effort remained relatively low-key and free from serious political controversy. The main problems appeared to be the coherence of the program, spread among a number of loosely related projects on campuses across the country, and difficulties in establishing projects on a scale larger than support for individual university faculty members and their students. The "small scale" tradition was particularly entrenched in social science disciplines and the ARPA effort was one of the first endeavors to try to break this down. The office appears to have had mixed success in this regard, but did manage to establish what were to become continuing larger-scale efforts in quantitative political science and computer-associated fields. These tentative starts were to be submerged for some time by the foreign area research effort and its ensuing controversy, but were to emerge again as the dominant programs following the

* DOD roles were many and varied: "show the flag;" create and/or train an army, navy or air force; teach "civic action" or some other version of using armed forces in economic development roles, etc. Teaching "counterinsurgency" was a particular favorite in the 1960's.

Vietnam-related controversies of the late 1960's. The ARPA behavioral science program of the 1970's bears a considerable legacy from early work on teaching and learning, bargaining and negotiation, and related fields.

Sproull, who was genuinely interested in establishing a social science research program of the highest quality, recalls that the only hostility to basic research that he ever encountered on the Hill was in the social sciences. Despite the fact that the existence of the program was not seriously threatened, there was "a definite and long-standing hostility."[104] Originally it was rooted in an intense Congressional fear of "thought control" that dates back to World War II. Government support of anything that smacked of "thought control" was forbidden fruit and to many on the Hill the "behavioral sciences" were the sciences that manipulated men's minds. Later "foreign area" research was to become the lightning rod. Looking back on his relationship with the Congress, which was for the most part "very warm and mostly friendly," Sproull recalls: "We spent more time on that little bit of social science research than on not quite everything else put together." [105].

Propellant Chemistry

By 1964 ARPA's propellant chemistry program was in process of being transferred to the Services. The major part of the transfer was accomplished at the end of FY 1964. ARPA involvement ceased in FY 1965. With the termination of this program, Project DEFENDER was left as the sole remaining survivor of the first wave of 1958 post-Sputnik assignments to ARPA.

The transfer of the propellant program appears to relate mostly to the fact that it never lived up to initial hopes for major breakthroughs; that it became increasingly dominated by highly specific technical problems and basic research efforts, the general importance of which were difficult to assess; and that the requirement for a high priority ARPA effort became somewhat obscure as Service programs became committed to various existing propellant types (and as the Services continued to support their own propellant research efforts). Dr. Ruina claimed that he was simply unable to assess the true significance of the effort,[106] and the same appears to be true of Dr. Sproull and ODDR&E (which eventually insisted on the transfer).

To indicate the program's character in 1964, an ARPA report on July 31, 1964 provides no ambitious overall program objectives similar to the early statements that the project would strive for a 10-20% increase in specific impulse of propellants. Rather the program is described in terms of technical coverage:[107]

> This program was initiated in 1958 to discover and develop new, high energy solid, liquid, and hybrid propellants. Primary emphasis was placed on the synthesis of oxidizers and fuels, scale-up and evaluation of the more promising chemicals with secondary emphasis on thermochemistry, combustion, and nozzle research.

Further discussion of rogram content included the following typical references:

> Recent emphasis on basic research on ionic oxidizers has led to the identification and characterization of two new NF ions.... Efforts continue to define the conditions for the preparation of crystalline bryllium hydride.... Combustion instability has not yet lent itself to an analytical model which adequately defines it, but progress has been made. Many of the parametics affecting acoustic sources and sinks have been isolated... explosive sensitivity is another example of an extremely complex, poorly understood phenomenon.... ARPA is supporting several approaches to this problem, but at this time much remains to be done.

Thus the impression given is that of an honest, highly technical program with few exaggerated claims. Practically the only assertion of program impact made in the report is that studies of combustion phenomena provided "back-up research" which may have given technical confidence to the designers of SPRINT and HIBEX and thereby enabled them to set their performance objectives higher than would otherwise have been the case. This influence would have been indirect and difficult to establish one way or the other.*

According to Dr. Sproull, cancellation of the solid propellant project was the result of a decision by the DDR&E on the recommendation of his Assistant Director for Chemical Technology (Dr. Jack T. Thurston). Sproull concurred that the project "had ort of run its course," but initially resisted transfer because he thought that the ARPA program still played a role in "information evaluation, comparison and exchange," a function which DDR&E was unable to convince the Services to take over.[108] Dr. Brown, however, ultimately supported the recommendations

* The project director for ARPA's HIBEX program, however, gives little credit to the solid propellant program in influencing HIBEX design; Dr. Sproull concurs in this assessment.

of his staff and the program was transferred.

Incidentally, the transfer of the project was quite controversial at the time as the following excerpt from a March 1964 Missles and Rockets article attests:[109]

> The ARPA chemistry program had three main objectives -- to commence and maintain a concerted effort in chemical research, to directly coordinate all propellant chemistry work and to get the chemical industry involved.
>
> A strong movement into the chemistry of propellants has been achieved, and the greater part of the chemical industry has been using ARPA as their focal point in DOD.
>
> ... There is some feeling among industry chemists that the Services, because of their understandably parochial outlooks, will not provide the type and kind of direction that has been available in ARPA.
>
> Several industry experts have termed the move a step backward -- as it might well be, since the upper level of executive ability within DDR&E will then lack adequate representation in basic chemical research.
>
> With the possible exception of pharmaceuticals, the chemical industry has always been the one major sector of the business community with a long standing and demonstrated faith in basic research.
>
> The Defense Department has had to drag all others into adopting this viewpoint over the years.
>
> But this devotion to research has often resulted in a deliberate avoidance of federal interference. Most of the DOD-sponsored chemical research work has gone to areas outside of the classical chemistry industry. This has resulted in the creation of a powerful and advanced industrial complex foreign to the historical chemical community.
>
> The federal funding is thus altering the shape of the chemical industry....
>
> While the past attitude of the chemical industry as a whole may somewhat weaken their argument against the shift of advanced or high-energy propulsion research from ARPA to the services, there is some justification in the claim of a loss of direction.

Assessing the impact of the propellant program transfer is difficult. On the one hand, the chemical industry did lose a central focal point of research support because the efforts transferred to the Services quickly became diffuse and lost any resemblance to an integrated program. On the other hand, there is a case to be made that propellant research should be closely connected with planned end users since, for example, considerations of storability and safety under specific conditions are highly important. Dr. Sproull personally tends to give credence to this view. In addition, the value of the ARPA program's output was questionable. Sproull tended to think that some of the propellant developments were "laboratory curiosities," and stated: "I can't recall, however, that until the time the thing was cancelled there was any end use."[110] Throughout, it should be noted, this program -- supervised for the most part by Dr. Gene Mock -- received very high marks for technical management.

Dr. Sproull's retrospective view of the project is that it was one of those "high risk" or "anti-technological surprise" efforts that did not have an output of major importance, but could have had a major impact.[111] In this context it is worth recalling the remark in Kistiakowsky's March 1958 report, cited above in Chapter III, that a research program would either show results rather quickly (2 years) or "prove that efforts in these directions are nearly futile."[112] It took ARPA about seven years to wind this program down, probably because: (1) someone could always state a reason for "hoping" that something significant would occur, (2) inertia, (3) lack of desire to terminate another large program after the traumatic experiences of the Roy Johnson period, and (4) the absence of critics. Sproull feels that it was "worth wasting years and millions" because of the very high payoff if a breakthrough in propellant technology had been achieved.[113] Engaging in "high risk-high payoff" research means that there will be failures, and -- in Sproull's view -- this program may properly be justified as one such high risk effort.[114]

Energy Conversion

As noted in the section on the Ruina period, the fate of the energy conversion work was sealed as early as 1961 when a decision was made to focus on a few transferrable projects rather than to expand the effort into a broad-based program of basic research support. Dr. Sproull, therefore, presided over an essentially predetermined project cancellation. The July 1964, ARPA report reflects this decision to terminate: [115]

> Project LORRAINE which has consisted of research devoted to direct energy conversion (the conversion of chemical or nuclear energy directly into electricity without dynamic machinery) was concentrating on applied research in Fiscal Year 1964 and is being phased out in Fiscal Year 1965.

What had ARPA accomplished in this brief excursion into energy research and development? Dr. Sproull feels in retrospect that the amount of money which ARPA could afford to put into energy conversion was so trivial "we just did not have much business being there ... the chances of making the world different were really pretty slight." [116] Sproull felt that "the real center of gravity in energy conversion had to be elsewhere," namely in industry and the civilian agencies.[117]

A look at the work effort within the program tends to support this view of minimal impact. Research on improving the efficiency of thermoelectric devices, for example, totalled only $500,000 over a three year period -- hardly a significant level of support. Research on solar energy conversion was funded at $1.3 million for one year only. Research in thermionic materials and diodes was funded over a four year period at levels between $200,000 and $1,200,000, in contrast to Navy, Air Force, NASA, and AEC programs totalling perhaps $10 million per year.

The largest ARPA effort in energy conversion was in research on fuel cells, fluctuating between $1.4 and $2.5 million over five years. ARPA's effort here was again a fraction of national funding, but did focus on a particular type of fuel cell -- so-called terrestrial cells -- and gave research in this area a distinct boost. Results, however, were apparently modest:[118]

> Progress toward a feasible hydrocarbon-air cell has been promising but not sufficiently exotic to either encourage unsupported commercial financing of the program or to allow ARPA to spinoff any significant portion to the Services.

The other major area of ARPA energy conversion work was in magnetohydrohynamics (MHD). This is perhaps the one area of the program where LORRAINE may ultimately prove to have major lasting impact. The program was aimed at:[119]

> ... both support of basic research toward understanding of the principles of MHD and using this understanding to test the feasibility of open and closed cycle MHD. In the beginning of this program virtually all of the federal support for MHD was provided by ARPA.

ARPA provided critical early support to AVCO and General Electric, among others, who continued to be leaders in the MHD field after ARPA withdrew. In fact, the initially ARPA-supported AVCO program proved to be the one U.S. program on practical power generation still in operation (with industry support) in 1971, when interest in MHD was revived. MHD has been given greatly increased attention recently as a potential means to significantly improve electric power plant efficiency and thus contribute to a solution of the nation's energy problems. While it is impossible to measure precisely the lasting import of the impetus ARPA gave to this technology in the early 1960's, it appears to have been significant. Since only $3.7 million was invested in MHD, and $22.8 million in all of LORRAINE, over the course of the program, the long-term potential savings of MHD technology would more than justify the entire LORRAINE budget if its impact is at all worthwhile. Post-1980 hopes for MHD lie in raising power plant efficiency from 30-40% to 50-60%, so that potential multi-billion dollar savings are ultimately envisioned.

If, however, this rather marginal ARPA program may have had a lasting importance beyond that indicated by its modest funding level and short life, one may well ask whether any major bets were lost by the project's termination. Federal research support for MHD nosedived following 1965, and in the late 1960's MHD was being funded by the Bureau of Mines at a level of only $300,000 per year.[120] ARPA may not have been the proper place to continue support, due to military relevance considerations, but it was apparently almost the only source of funding for this advanced technology in the 1960's. As a product of the current energy crisis, there is also greatly increased interest in the other energy conversion technologies once supported by ARPA, e.g., advanced fuel cell technology, thermoelectric devices, etc. ARPA's role in this field may therefore have had greater potential influence than recognized at the time, when the decision to contract rather than expand the effort was made. One wonders whether a stronger ARPA might have stayed the course in this difficult area, to the benefit of DOD and others. But it could not. As Sproull said:[121]

> People always said that ARPA didn't have any judgment. We would always rush in where fools fear to tread. But that's not quite true. We did sometimes fail to rush in ... that was one of the cases.

SPROULL'S DEPARTURE

By pre-arrangement Dr. Sproull left ARPA in July 1965 after two years on the job to return to university life. While some new initiatives had been undertaken, some old efforts curtailed and several projects modified, ARPA's basic profile remained about the same as it was when he arrived. He left an ARPA with a strong technical reputation and a reasonably solid bureaucratic position. He did not leave a menu of ideas for "new starts;" indeed by this time it seemed to have become an unwritten code that ARPA Directors not commit their successors or tie their hands in any way. ARPA was not planning for the future. It seemed happy to pursue existing programs and to await the future in a reactive posture.

A few "Why ARPA?" questions reappeared during the Sproull period. AGILE was becoming an irritant to the Deputy Secretary (the former Secretary of the Army, Cyrus Vance) and as direct U.S. involvement in Vietnam increased the Services took aim at it. Sproull felt that the love-hate relationship with the Services "was probably the strongest fact of life for ARPA."[122] On the Hill, Congress was perturbed with behavioral research and gradually with AGILE and its association with "gadgets" that had a questionable connection to R&D. Congress was also starting to criticize unobligated balances in the DOD RDT&E accounts, including ARPA's. Most of the pressure at this stage was directed to the DDR&E, who in turn began to push ARPA. Sproull got little direct questioning about it from the committees. Sproull could sense that challenges were coming, although nothing of a threatening nature was evident when he left:[123]

> [There was] a kind of generalized pressure to make the Agency look different. Year after year I felt [that] unless it looked differently ... you had a harder time justifying it to Congress, and a harder time getting your authorizations in DDR&E and so on. There was always some driving force to make the Agency look different.

Sproull's successor as ARPA Director appears to have been an almost automatic choice -- Dr. Charles M. Herzfeld. Acting Deputy to Ruina and Deputy to Sproull, Herzfeld had held continuing responsibilities for the DEFENDER program since his elevation from being head of that office, and had been delegated considerable authority by Sproull. Aside from the fact that DEFENDER remained the largest ARPA program, a new decision point on ballistic missile defense was fast approaching, namely, whether and when to deploy some version of the new NIKE-X system and the implications of that decision in defining the continuing role of advanced BMD research. Highly qualified in this area of great technical debate and a vigorous spokesman for a strong ARPA in this and other areas, Herzfeld was a logical choice to succeed Sproull almost from the day of Sproull's appointment. Furthermore he wanted the job.

CHAPTER VI: FOOTNOTES

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8. Discussion with Dr. H. F. York, April 4, 1975.
9. House Subcommittee on Appropriations, *DOD Appropriations for 1965*, Hearings, 88th Cong., 2nd Sess., Part 5, March 2, 1964, 154.
10. Discussion with Dr. R. L. Sproull, May 29, 1975.
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15. *Ibid.*
16. *Ibid.*
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18. Discussion with Dr. C. M. Herzfeld, May 7, 1975.
19. *Ibid.*
20. Discussion with Dr. R. L. Sproull, May 29, 1975.

21. Discussion with Dr. J. P. Ruina, June 26, 1975.

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28. Discussion with Dr. A. Rubinstein, February 21, 1975.

29. Discussion with Dr. S. Rabinowitz, May 21, 1975.

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32. Discussion with Dr. D. Dustin and Dr. J. Freedman, July 2, 1975.

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34. Discussion with Dr. J. Foster, Jr., July 9, 1975.

35. Discussion with Dr. E. Rechtin, July 7, 1975.

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39. House Subcommittee on Appropriations, DOD Appropriations for 1968, Hearings, 90th Cong., 1st Sess., Part 3, April 3, 1967, 197.

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Chapter VII

THE CONTINUUM IS BROKEN

THE HERZFELD YEARS: 1965-1967

On June 6, 1965, Dr. Charles M. Herzfeld became the fifth Director of the Advanced Research Projects Agency. He had been with the Agency for almost four years, having joined DEFENDER in the fall of 1961. He was promoted to Deputy Director of the Agency in 1963. Like his predecessors, Herzfeld had come to ARPA with a strong technical background, including a degree in chemical engineering from Catholic University and a Ph.D. in chemical physics from the University of Chicago. He also brought to the post an impressive career in Federal research and development programs, with military service in the Army's Ballistic Research Laboratory and civilian service in the Naval Research Laboratory and the National Bureau of Standards. In the latter organization he had risen to the level of an Associate Director prior to coming to ARPA. While pursuing this government career, Dr. Herzfeld also gathered considerable teaching experience at the University of Maryland, where in 1957 he became a professor of physics.

Dr. Herzfeld assumed the ARPA Directorship in circumstances quite different from those of his two immediate predecessors. While he shared many background characteristics and attitudes with earlier Directors and was the first ARPA Director who had "risen from the ranks," there was nevertheless a certain aura of dissonance about Herzfeld's ARPA. Conflict increasingly seemed to be the order of the day and in many instances resolution was ephemeral, temporary or simply impossible.

The Setting -- 1965

The major change in the ARPA environment in 1965 was, of course, acceleration of the war in Vietnam and its wide repercussions on the entire DOD environment. At the end of 1964 there were some 23,300 U. S. troops in Vietnam; one year later there were 184,300. Whereas only 147 U. S. Servicemen were killed in Vietnam in 1964, almost ten times as many were killed in 1965. The political situation in Vietnam also appeared to be going from bad to worse. In the first half of 1965 coups and counter-coups came in rapid sequence, ending with the assumption of power in June by the flamboyant and controversial Marshal Ky.

When Sproull had become ARPA Director in 1963 the Vietnam War situation appeared to be under some control and the mood was quite optimistic. As McNamara and Taylor reported to Kennedy on October 2 (following a visit to Vietnam): "... the major part of the U. S. military task can be completed by the end of 1965, although there may be a continuing demand for a limited number of ... training personnel."[1] By the time Herzfeld assumed the ARPA directorship in 1965, however, the situation had changed considerably. McNamara's comment on February 19, 1965 is illustrative: "the present situation in South Vietnam is grave, but by no means hopeless."[2]

The domestic repercussions of the Vietnam conflict in 1965 were equally as important as the developments in South Vietnam. 1965 was clearly the turning point in the previously good relationships between the academic community and the Defense Department. Prominant university professors and academics led a rash of "teach-ins" in the spring, coupled with campus demonstrations throughout the country. Draft card burning became a common form of student protest and Congress passed legislation on August 13 making the act a Federal offense, a move felt by many to be needlessly retaliatory. Campus-based organization of the March on Washington occupied much of the fall, culminating in the massive gathering on November 27th. By the end of 1965, university-DOD relations had deteriorated to a low level from which it would take many years to recover. ARPA's strength in the early 1960's was, of course, based substantially on its role as a bridge between the two communities.

Vietnam, however, was not the only development in 1965 which had a profound effect on ARPA's environment. In late June the so-called "Camelot" episode hit the headlines. The incident concerned an Army social science project on insurgency and political unrest and was touched off by the questionable activities of a study consultant in Chile who had not cleared his work with the American ambassador. Banner headlines, first in Chile and then in the U. S., seriously questioned the legitimacy and purposes of this work, leading to considerable debate about the ethics of doing behavioral science research for the Defense Department. Repercussions extended from hostile debate between the academic community (and press) and the DOD, to bitterness between DOD and State concerning the latter's handling of the affair. Though ARPA was not involved in this episode, its behavioral sciences effort was threatened by the affair and behavioral science research remained a highly controversial aspect of the ARPA program into the 1970's.

Beyond the above, McNamara decided in 1965 to reject NIKE-X deployment for the foreseeable future. This decision was resented in parts of the Army and the Congress, and was not fully accepted by the Administration, which reversed it in 1967. It also raised questions about the role of ARPA's DEFENDER program and about the ARPA Director's position on ABM deployment. Bitterness over the TFX controversy (F-111) lingered on within the Defense Department; the invasion of the Dominican Republic sparked serious debate over the uses of U. S. military force; the outbreak of Indo-Pakistan hostilities undercut U. S. foreign policy and military assistance programs; sharp increases appeared in Defense budgets, accompanied by great pressure to control R&D expenditures in order to prevent still more rapid escalation (the budget rose from $49.6 billion in FY 1965 to $56.8 billion in FY 1966; 85 per cent of the increase, or $6 billion, was for Vietnam).

1965 was therefore a most difficult year for the Department of Defense and for the country as a whole. As Senator Dirksen stated, the following year, "Today what appeared to be a golden glow only two years ago has been broken by rolls of thunder ... and uncertainty, queasy doubts, bewilderments have spread across the country."[3] His language was florid, but the point entirely accurate.

DDR&E Perspective on ARPA

The events of 1965 provided a setting for Dr. John Foster's arrival as Director of Defense Research and Engineering, as well as Dr. Herzfeld's promotion to Director of ARPA. Appointed in September, three months after Herzfeld's elevation, Foster's perspective on ARPA must have been influenced by current events. DOD-university relations had just dropped to an unprecedented low; ARPA was deeply involved in large programs of basic university research, governed only by quite broad criteria of relevance, e.g., materials laboratories, the Arecibo radio astronomy facility, a half dozen basic research institutes funded under DEFENDER, university seismology programs under VELA, support for advanced computer research, and others. In Vietnam U. S. forces had shifted from advisory roles to large-scale direct military involvement, including combat; ARPA's AGILE program was focussed on such matters as environmental measurements programs and various forms of R&D support to indigenous forces. The Services were stepping up their criticisms of ARPA/AGILE. The DOD's behavioral sciences research effort was under bitter attack; ARPA supported a multi-faceted behavioral science program which touched upon many of the most controversial issues. Serious budget problems had arisen with the suddenly accelerated Vietnam requirements; ARPA was providing as much as four years of advance funding to universities and tolerating sizeable unobligated balances, accumulated in all its programs. Criticism of ARPA on these and other grounds was rife at the time Foster joined the DOD.

Foster confirms that there was a definite "why ARPA?" environment when he arrived. The feeling existed in OSD, and even within ARPA, that "ARPA was doing things that were not important, or that somebody else ought to do, or that were more trouble than they were worth."[4] There was strong sentiment that ARPA was not playing the role it once had, that many old assignments had outlived their usefulness, and that a number of activities were being carried forward simply because of people who had been there for too long a time. Some of the critics, of course, wanted to do the job themselves or wanted ARPA's flexibility. McNamara apparently was disillusioned with ARPA, and Deputy Secretary Cyrus Vance came to advocate abolishing the Agency. At one stage, the criticism was so intense that McNamara asked to see every report coming out of ARPA.[5]

According to Foster, who had considerable prior association with the DEFENDER community and considered himself a supporter of ARPA, the situation was bad enough that one could not simply tell the critics to go away.[6] He felt that opponents in the Services and in OSD had some legitimate points to make and often had the reputation and contacts to spread uneasiness and discontent in Congress and in the Secretary's office. Indeed he felt "outnumbered by critics" of ARPA who had that kind of horsepower. Nonetheless, comparing ARPA with its competitors, dollar for dollar, over time, Foster said: "I liked what I saw. It all depends on the Director and the people and the charter."[7] He eventually decided that changes were required in all three.

Why had ARPA fallen into this state? In Foster's words, "There was too much toleration of an academic atmosphere" in an era when the DOD and academia had abruptly parted company and top priority was being given to rather precisely defined Defense-relevant tasks.[8] Arecibo-type "good science" projects were looked upon as luxuries: "The Secretary of Defense had a limited budget and could not take on the job of doing science and technology for the whole country and defend it before the country."[9] ARPA's reaction typically (and perhaps naturally) was to dig in and defend its projects rather than make concessions or offer compromise adjustments. This further incensed the critics. ARPA, said Foster, had the image of desiring the "perquisites of academia and the power of bureaucracy," and generated intense resentment as a result.[10] Beyond this there were perceived weaknesses in the Agency's management performance, e.g., its toleration of large unobligated balances ($60 million in FY 1965), overgenerosity to the universities, etc. Moreover, in Foster's judgment, ARPA had failed too often in identifying customers for its research output and in working on a smooth transfer process from the very outset. Hence too many isolated "sandboxes had grown up that needed to be cleaned up."[11] But perhaps as important as anything else was simply a much lower threshhold of irritability throughout the DOD as pertains to roles and missions conflict, budget competition and the like, given increased criticism of and additional constraints on the Defense Department as a whole.

Herzfeld's View of ARPA

In the midst of growing criticism of the Agency and discontent throughout the Department, Herzfeld became ARPA Director with a vigorous, aggressive view of ARPA's role. Herzfeld felt, and told Congress, that "much of the work which ARPA did was the reason why the Army changed from NIKE-ZEUS to NIKE-X"[12] and that much of ARPA's work "induced the Air Force and the Navy to change from the unsophisticated ballistic missiles to the highly sophisticated ballistic missiles being procured now."[13] Herzfeld was a strong believer in the AGILE program, felt that the U. S. was winning the war in Vietnam and argued that ARPA's counterinsurgency R&D activities had a major role to play (and in retrospect he argues that the Southeast Asia situation ended in disaster partially because ARPA/AGILE's views, as he interpreted them, did not prevail).[14] He also believed that the VELA program was of first order national significance, claiming that VELA and

DEFENDER together had made the Limited Test Ban Treaty possible. VELA furthermore had twice "really revolutionized seismology:" first, through its broad support to the field and, second, through the LASA program.[15] He was a strong supporter of the information processing program, feeling that Licklider's commitment to interactive computing had set a true "vision of the next ten years."[16] His presentations to Congress emphasized the spectacular successes of the day -- the VELA satellites, the HIBEX launches, etc. Thus Herzfeld's view of ARPA, echoing Ruina and Sproull, was that of a strong, independent, freewheeling organization: "I think that's why it was such an exciting thing, because we really could do what we thought was new without anybody stopping us."[17] That was one of the problems troubling the new DDR&E.

Perhaps more than any other Director, Herzfeld insisted that ARPA's major role was to respond to "Presidential issues," those of high national policy concern, and again perhaps more than other Directors, he argued that ARPA's strength derived from its direct utility to the Secretary of Defense. In the context of DEFENDER, clearly Herzfeld's priority program, he believed that ARPA's contribution derived from the fact that:[18]

> [I]t was found useful by successive Secretaries of Defense and DDR&E's to have a powerful pacesetter for the Army program; and their [the Army and ARPA] competition, in fact, resulted in a better Army program.

Herzfeld, in reviewing his ARPA years, frequently reiterates the importance of ARPA's presentations to McNamara, and of McNamara's support for ARPA as a strong, independent force (particularly in the context of DEFENDER). The DEFENDER program's knowledge of advanced technology, Herzfeld asserts, was used by the Secretary "very unmercifully to beat the Army over the head."[19]

Herzfeld held strong views on major policy issues like missile defense deployment, nuclear test detection and the conduct of the war in Vietnam. His elaborate Congressional presentations were alleged to have become irritants in ODDR&E and at higher levels. In a sense, the propriety of what appeared to be an ARPA presumption to independent status at the policy level was challenged. Herzfeld concedes that the Vietnam situation was especially difficult to deal with:[20]

> Naturally everybody who didn't agree with what we [the U. S. were doing in Vietnam, which in those days was mostly Republicans .... obviously tried to get me into discussions with them that would somehow discredit the policy. This is a very difficult sticky-wicket because we didn't agree with the policy a lot because we thought

> it was not based on adequate information. And I guess if one reads off the testimony carefully enough, one can get a lot of that flavor -- it's delicate. Occasionally, I guess, we overstepped the line, intentionally or not.

Internally, the DEFENDER philosophy which Herzfeld developed and inculcated in that program while he was its director also reflected his general order of priorities and orientation for the Agency as a whole:[21]

> Several key points. It's got to be useful to the military in the end. On the other hand there will never be a uniformed service called ARPA, so that [the user] has to be a military service. It's got to be useful in 10-20 years, or sooner if possible. It's got to affect what the military are doing and what the leadership is thinking and doing. It's got to address the Presidential issues.... It's got to be based on measurement as much as possible. Whatever it is. You have to have measurements.... You want to try and understand everything about those measurements, therefore, a lot of theoretical analysis.... Last, and certainly not least, you have got to at every stage understand the systems implications somewhat. So some system design and some system analysis, including cost-benefit analysis, has to go on all the time.

Herzfeld thus argued for military relevance in ARPA programs, but relevance perhaps achieved over a long time period; for concentration on problems of first-order national importance; for strong measurements and theoretical analysis efforts; and for attention to "systems implications." This latter emphasis, incidentally, was to carry over strongly into the AGILE program as it developed during Herzfeld's tenure and became a very controversial aspect of the counterinsurgency research program (particularly in Thailand) following his departure.

Herzfeld also believed in the research values associated with PSAC and Ruina and Sproull:[22]

> [T]he administrator of the basic-research enterprise must ... learn to appreciate the rare nature of creativity, its importance to society; and he must learn to protect and foster it ... the administrator must learn to encourage creative rebellion, outspoken criticism and radicalism in the ranks. He must see the fine line between

> utter chaos (which paralyzes) and mild chaos (which makes for creative turbulence). In sum, he must learn that administration is not a science, but is itself a form of creative art.
>
> Society must learn to live with this radical -- the creative scientist doing basic research. It must support him -- rather well, in fact -- and buy him expensive "toys" whose use society cannot understand ... most important, it must believe in him and in his contribution to society, a contribution which it can never fully understand.

Alongside his vigorous defense of a strong, relatively independent ARPA and the pursuit of excellence in research, Herzfeld also placed great stress on the quality of ARPA staff and contractors (as did his immediate predecessors). Herzfeld claims that he devoted up to one-third of his time to personnel matters and recruiting. Furthermore, he placed great value on "what he termed "helper" organizations -- JASON, RAND, IDA, and other so-called "think tank" contractor groups that enjoyed a special sort of consulting relationship with the Department of Defense during the 1960's. The capabilities of these groups were tapped very heavily by Herzfeld to supplement the small ARPA technical staff in numerous areas.

Herzfeld's ARPA was an aggressive ARPA. He was dedicated to the resolution of major issues and as he took command ballistic missile defense, penetration aids, counterinsurgency, and nuclear test detection offered a full menu. Herzfeld was convinced that ARPA could produce winners in all of them; however, in the relatively short time that he served as Director -- 22 months -- he and the Agency rapidly lost the ability to resonate well with the personalities, policies and circumstances which crowded in upon them. In retrospect, for all its vaunted flexibility, ARPA was unable to change as quickly as the environment within which it had to operate. Dr. Herzfeld had to deal with the most difficult, intransigent set of pressures since the end of the Roy Johnson period.

PROGRAMS IN THE HERZFELD PERIOD

An overview of ARPA programs in the Herzfeld period gives a first impression of strength and accomplishment, but reveals some disturbing features on closer inspection. At the time Herzfeld became Director, ARPA had reached its post-space budgetary peak -- just under $300 million -- and all of the major programs of the Sproull period continued to flourish (see Figure VII-1). DEFENDER budgets remained near $125 million; VELA was funded at approximately $50 million; AGILE, its budget bolstered by the DOD's increased Southeast Asia commitments, rose to nearly $30 million; Materials Sciences and Information Processing were funded at approximately $20 million each; the new Advanced Sensors office grew to over $10 million and Behavioral Sciences to almost $5 million; even the general area of

Figure VII-1

PROGRAM BUDGET HISTORY DURING THE HERZFELD PERIOD
($ millions)

	FY 1966	FY 1967	FY 1968
Appropriations Requests	277	263	254
Actual Budgets	274	263	249
Commitments To Agents	280	270	232
Contract Expenditures[1]	267	275	284
Requests By Program:			
DEFENDER	127	119	118
VELA	59	49	50
AGILE	30	29	27
Materials	28	29	19
Information Processing	19	18	19
Behavioral Science	4	5	5
Advanced Sensors	5	10	12
Technical Studies	9	9	9

[1] Added to illustrate that while budgets declined in the period, level of effort on contracts actually increased. A major issue relating to the budget slippage during the period was that ARPA had large unobligated balances of funds. The program was maintained at a stable level through utilizing accumulated balances of previous years.

"technical studies" grew to nearly $10 million. On the other hand, Herzfeld's last budget request as Director (FY 1968) dropped from earlier levels of $270-$290 million to $254 million, reflecting Vietnam budgetary pressures and perhaps also some difficulties in maintaining program momentum.

Among the features of the Herzfeld ARPA which provided some cause for concern was the extent to which offices were tied up with rather expensive past commitments. PRESS, for example, was still providing valuable data and analysis output, but the maintenance and continued upgrading of the facility was a major burden; nor could it hope to repeat the initial impact which had been achieved in a near vacuum of sophisticated reentry measurements. Continued launches of VELA Satellites likewise brought new, improved capabilities, but at substantial expense and with no hope of replicating their extraordinary initial success story. The Materials IDL's were now part of the university establishment, absorbing some $17 million per year on a continuing basis. The innovative Project MAC at MIT was increasingly preoccupied with its expensive MULTICS second-generation time sharing system. Even AGILE had an ever-growing infrastructure to support in the form of its field office operations.

If ARPA's flexibility was restricted by the legacy of its past successes, there were also a substantial number of relatively new initiatives which at the time or later generated considerable misgivings, and many of these efforts were also quite expensive. In Information Processing Techniques, the commitment to build the giant ILLIAC IV computer has been questioned up to the present. In VELA, the Large Aperture Seismic Array program failed to reach its more ambitious systems objectives and was reduced to a rather costly research program; the underwater array program also proved a technical disappointment. The Materials Sciences "coupling program" failed to become the success anticipated. The Advanced Sensors* office, its operation greatly complicated by its relationship to intelligence applications, was questioned from the beginning. A large Rural Security Systems Program established in Thailand under the AGILE banner became a fiasco in the next few years.

Between commitment to older programs which had passed their peak impact and newer programs which proved considerably less successful than earlier initiatives, the ARPA effort appeared to lose a substantial measure of its forward motion and drive. With this, it also lost some of its ability to go to the DDR&E or the Secretary with the kinds of dramatic accomplishments which buttressed the Agency's reputation and stature. This is not to say that the ARPA program as a whole was not strong in numerous ways -- PRESS was still very significant, Pen Aids work flourished, ARPA remained in the forefront in advanced information processing

* Due to the highly classified nature of many of its programs, Advanced Sensors is described only in outline form in this report. Discussion is omitted in this section and continued in the program descriptions of the Rechtin period.

technology, VELA continued to make major contributions to seismology and the satellites performed beautifully, etc. The Agency was, however, in the almost impossible position of having to sustain established fields of endeavor and yet "live up" to a reputation originally set in the context of filling important technical vacuums, where results frequently were obvious and dramatic. The earlier "primitive" fields -- reentry physics, modern radar, seismology, interdisciplinary materials research, advanced computer sciences, etc. -- were no longer primitive, largely due to ARPA support. Now ARPA was obliged to sustain them, and new fields of equal importance and equal need for nourishment were not easy to find.

DEFENDER

The DEFENDER program structure in 1965 had changed little from that of 1963. The categories of penetration aids, electromagnetics (mostly advanced radar research), mechanics (including predominantly HIBEX), and missile phenomenology (PRESS, AMOS, etc.) remained the same. The category General Research had been changed to Applied Research, implying greater military relevance, but it still contained about the same project mix, e.g., Arecibo, nuclear effects studies and university institute programs. A new category of Systems Analysis was formed which essentially encompassing various broad studies which were previously described just as "studies." The reentry physics-missile phenomenology work still formed the largest part of the program and the DEFENDER effort continued to be funded at a basically stable level (just under $125 million). A quick glance at the 1965 DEFENDER therefore reveals little change from the program at the time Sproull became Director in 1963.

There were, however, a number of significant developments occurring in DEFENDER as Dr. Herzfeld became Director. One major accomplishment was completion of the massive "Pen-X" study in July 1965. The study is said to have had a major impact on advanced penetration concepts and recommended changes in emphasis in ARPA's program in specific technical areas. According to Dr. Ben Alexander, the study Director, Pen-X reinforced both the Air Force's interest in MIRV's and the AEC's interest in small warhead development and may have considerably stimulated developments in both areas.[23] In layman's terms, the study essentially concluded that the tradeoff between small multiple warheads and a single larger warhead accompanied by sophisticated decoy systems was favorable to the former. Or, as Herzfeld put it "Pen-X proved that, for all practical purposes, multiple warheads are better than decoys [and] that's why MIRV's are around fella's."[24]

ARPA provided the funds and general direction, and often much of the impetus, for a series of these so-called "X" studies at crucial points in the evolution of the U. S. scientific/technological community's thinking about missile defense. Each has had rather far-reaching impact on subsequent policy choices. Customarily they involve dozens of top-flight scientists, last for months and may cost several million dollars. Herzfeld has described them as "sort of mammoth study orgies."[25] And he believes that nothing short of an ARPA can orchestrate them:[26]

> [T]here is no direct funding out of OSD to speak of [for something like this]. And there certainly isn't any [place] where you can get a good quality control for something that's this technical. See, again, it's the issue of how do you know that the money is spent right, which faced a Brown, a McNamara, a Ruina, a Foster. The answer is let ARPA run it.... [I]f it's a program that involves maybe ten organizations, a hundred technical people, all three Services in a major way, for a year's important study, that you plan to use the results of, well you'd better get it right. And you really, in terms of justifying the expenditure to yourself and others, have to know that it is being done right. Where do you go, even now, if you sit in OSD, and you have that kind of problem? ARPA. That's one of the things that ARPA is good at. Always has been and always will be, I trust, as long as there is one.

ARPA's role in advanced radar development also continued to evolve. The ADAR program had essentially developed from an advanced phased array components program to a prototype model development program, with the latter actually initiated in April 1966. During the same period, the HAPDAR low-cost phased array became operational at White Sands (in a receive-only configuration in October 1965 and full radar mode in June 1966).

New instrumentation radars for the PRESS program were also in development or in planning, and old equipment was modified and upgraded. Notable among these developments were the new ALCOR (ARPA-Lincoln Coherent Observables Radar) and ALTAIR (APRA Long Range Tracking and Instrumentation Radar). ALCOR was a high resolution radar with a capability to measure the length of reentry bodies and/or satellites. It made it possible to investigate length measurement as a BMD discrimination technique and also made a central contribution to intelligence applications in space object identification (SOI). This latter area of investigation has continued in ARPA following the DEFENDER transfer. The ALTAIR radar extended PRESS capabilities in the UHF and VHF ranges. Herzfeld had little patience with those who considered PRESS investments (cumulatively \$250-\$350 million) expensive. In his mind the \$10-\$20 billion U. S. investment in strategic weapons systems in fact depended on the PRESS measurements system for their success: "I think it's cheap for the money. I would have spent twice as much if it had been necessary. I would gladly have spent twice as much."[27]

The HIBEX program was successfully completed, with six of seven tests of this high velocity interceptor totally successful. Though the system was not "weaponized" as was the SPRINT interceptor, and was merely a research vehicle, its acceleration and maneuvering capabilities far exceeded the performance characteristics of SPRINT at perhaps a tenth the cost. To follow the HIBEX program, ARPA established two efforts: UPSTAGE (the upper maneuvering stage for the advanced interceptor) and MARCAS (maneuvering reentry control studies). Both thus focussed on maneuvering control techniques at very high velocities in the context of a reentry vehicle and a high velocity interceptor.

Numerous changes were thus occurring in the DEFENDER program, but were largely logical extensions of preceding work. There were no totally new major assignments to DEFENDER, the last really new additions being penetration aids in 1961 and HIBEX in 1963. The program was providing important research outputs, but not in quite the dramatic fashion of earlier years when phased arrays came on the scene, quality instrumentation radars were just coming into operation, and reentry phenomenology data flowed in to fill a near vacuum. As Herzfeld took office, DEFENDER was a thriving program entering a period of maturity.

The issue of whether and how DEFENDER was changing was to become an important issue at the end of Herzfeld's tenure when Foster posed the somewhat heretical notion of transferring the program to the Army:[28]

> I kind of objected to that [argument] because there was constant change in the programs. And one of the arguments in favor of transferring the program out was that it needed to get a change. I think that was completely wrong-headed and that argument was made by people who didn't really know the program well enough to make that judgment.

<u>The Evolving Crisis in DEFENDER Identity</u>. While DEFENDER had gradually attained the status of a mature program -- well integrated into the national BMD and strategic offensive systems efforts -- this very integration was beginning to raise questions about its continuing role. These questions foreshadowed developments in 1967 which would ultimately culminate in the transfer to the Army of the core of the DEFENDER program.

In the early 1960's, the ARPA and Army programs were distinctly different. ZEUS was a late mid-course BMD system based on existing technologies whereas ARPA's work concentrated on new technologies and led to systems approaches quite different from ZEUS, e.g., ARPA's work came to focus on late-terminal intercept (with atmospheric filtering of decoys), which simply was not feasible with the ZEUS system. While there may have been budgetary and deployment versus advanced research conflicts, the Army and ARPA programs were not "competitive" in the sense of striving to best one another in the same technologies and systems concepts.

This situation changed with the demise of ZEUS and the Army's adoption of NIKE-X. NIKE-X adopted phased array radar technology while ARPA work on phased arrays continued; both programs came to emphasize late terminal intercept concepts; both programs initiated work on high performance interceptors; and reentry phenomenology work underlay both programs. Moreover, the prospect of full NIKE-X system deployment in the foreseeable future had become extremely clouded (especially in the light of McNamara's well-known opposition to deployment). The remoteness of deployment thus led NIKE-X to move more in the direction of ARPA's exploratory development approach, whereas ZEUS advocates had tended to urge near-term deployment with few long-term exploratory development requirements.

By the time of Dr. Herzfeld's appointment as ARPA Director, changes in the DEFENDER-Army relationship had led to a great deal of concern on the part of the DEFENDER program head (Dr. Samuel Rabinowitz) that his program was gradually becoming indistinguishable from NIKE-X in broad outline and that redirection would be needed.[29] The problem, as he saw it, was to reconcile the need to be relevant to the NIKE-X program with the organizational requirement to maintain a separate identity.

As a solution to this dilemma Rabinowitz concluded that to avoid competition (in the sense of competing for the same mission or work effort) required ARPA to begin to plan seriously for transfer of projects in the most competitive areas (and those areas which were purely supportive of the Army program) and to begin to focus ARPA resources more consciously on the loopholes or gaps in the Army effort.[30] He foresaw a gradual reorientation which would retain enough of the old ARPA program to influence and educate the NIKE-X program, but would slowly build a more distinct DEFENDER effort; or perhaps even an effort quite different from DEFENDER, with the old missions and even the name gradually falling by the wayside. ADAR was noted as one candidate for transfer, as was the field measurements program. In fact, however, the "gradual transition" notion was not accepted in ARPA; consequently the transfer decision of 1967 was abrupt and brought about a severe management crisis. It was not pursued because Herzfeld disagreed with it. He did not believe that NIKE-X and DEFENDER were growing to be alike and he was philosophically opposed to the loss of OSD leverage over a Service, which a DEFENDER transfer would entail, in a critical "Presidential issue" problem area.

Regardless of the validity of Rabinowitz's rationale, his conclusion that planning for a non-DEFENDER future should be undertaken was deadly accurate. Failure to do so in this instance almost cost the Agency its existence. One of ARPA's biggest deficiencies, however, has been inability and/or unwillingness to plan ahead.* Herzfeld inherited it and in his relatively short tenure as Director had his hands full defending the Agency's programs and role. There was no time to apply to creating a planning system.

HIBEX. One of the outstanding DEFENDER successes of the Herzfeld period was the HIBEX interceptor program. Established in ARPA when Herzfeld was directing the DEFENDER office, the advanced BMD interceptor enjoyed its rather spectacular test achievements while he was Director of ARPA and films of these tests became special events at Congressional presentations. HIBEX was gradually transformed into the UPSTAGE program (the maneuvering upper stage for the interceptor) which also appeared to be a substantial technical success, but perhaps without quite the impact of the initial effort.

The purpose of the HIBEX program was to demonstrate the feasibility of a very high performance interceptor -- with both high acceleration and high maneuverability -- which might be able to engage a maneuvering reentry vehicle. Performance standards for the interceptor were set very high with reference to the currently existing state-of-the-art, e.g., perhaps ten times the performance characteristics of current interceptors. In order to achieve these advances, i.e., to accelerate to a few hundred G's and reach several thousand feet in a second, it was necessary to pursue several separate technologies at once. Advances were required, for example, in fast burning propellants, control mechanisms, gyro technology, auto pilots, and "hypersonic lifting" design.[31] Considerable risk-taking was entailed in the program; indeed, the first experimental interceptor was flight tested after only one static test, and each of the tested missiles differed significantly, as new features were constantly incorporated. For all this, the interceptor achieved the almost incredible record of six fully successful flight tests out of seven shots. In the meantime, the Army's SPRINT interceptor program, being developed in parallel, encountered continuous test problems in its early years and had a long string of early test failures. HIBEX had a modest 22 per cent cost increase over initial estimates (largely attributed to an explosion at a plant) and cost only a small fraction of the SPRINT development effort.

The director of the HIBEX program, Dr. Vahey Kupelian, attributes the technical achievements of the interceptor to a number of features of the ARPA approach to advanced R&D.[32] First, and most important, was ARPA's ability to maintain the effort as a clean experimental interceptor program

* A problem complicated by personnel turnover in DEFENDER, cited as "a waste" and a continuing issue by one of the contemporary DEFENDER staff members. (Discussion with A. Gold, April 24, 1975.)

and to resist pressures (which he feels would have been irresistible in a Service program) to turn the experiment prematurely into a prototype weapon. In his words, HIBEX was developed rapidly and successfully because it was not "weaponized," that is, because attention did not have to be given to the details of designing for incorporation of a warhead, long-term maintenance in silos, to making the missile "dust proof, bust proof, idiot proof."[33] Instead the program was able to focus exclusively on the central technical problems relating to interceptor performance and maneuverability. In contrast, the SPRINT was "weaponized" from the beginning, and its much higher cost and much slower start were related, in Kupelian's view, to the burden of all the additional requirements entailed in incorporating the developing interceptor into a fully-designed weapons system. The argument is basically that technical advances are achieved more efficiently by handling experimental development and weapons system development sequentially rather than concurrently, and ARPA is seen as especially capable of maintaining the integrity of the experimental development phase.

Other features of ARPA which Kupelian regarded as contributing to the technical success of HIBEX include the Agency's lack of bureaucratic restraints and its flexibility to tap very high calibre outside professional help as required. Service procedures were much more rigid and bounded by standing plans, proposals and contracts. Kupelian particularly valued ARPA's ability to follow up a promising development quickly and to focus on the key issues: "doing the right thing is much more important than doing it right. You can do it right the second time around."[34] Permissive contract selection procedures and the flexibility to use several agents for contracting were cited as major assets. The freedom of the individual program manager to make technical decisions was a further advantage, as opposed to the Services which have too many "spear carriers" or "horse holders" who have to be accommodated on the staff and thereby slow down the decision-making process.[35]

On the technical level, therefore, HIBEX was a spectacular achievement, and the achievement appears to relate to ARPA's ability to focus on the key technical issues. The program, however, is not without its critics. HIBEX/UPSTAGE, while later transferred to the Army with the other core DEFENDER projects, did not become the first phase of a new operational super interceptor. As of the mid-1970's HIBEX technology still "waits in the wings" for a decision to develop an alternative to the second-generation SPRINT now incorporated into the nation's limited BMD effort. Direct transfers to the SPRINT program, which was developed in parallel, appear to be rather modest (a point with which Kupelian concurs) though some spin-off did occur. Because the program never made the transition to a weapons system, some observers regard HIBEX as primarily an interesting "hobby shop" activity of no great significance.[36]

The response to the above criticism is largely that a very advanced interceptor technology has been developed at low-cost, which provides the basis for efficient operational developments should the requirement for an expanded ballistic missile capability arise, while at the same time the "arms race" implications of developing an operational super-performance interceptor have been avoided. Another argument is that the very existence of HIBEX impelled the Army to upgrade its specifications for SPRINT considerably and thus was an important prod to improving the operational interceptor systems which actually were developed in the 1960's This point appears well documented: SPRINT performance requirements were substantially raised almost immediately on the initiation of the "competitive" ARPA project. Thus the proponents of the point of view that HIBEX has been significant point to both a stand-by advanced capability and an incentive resulting in a stronger Army effort.

VELA

The VELA program organization remained essentially unchanged from earlier years. VELA Uniform continued as the major effort in underground test detection; VELA Cloud Gap was renamed VELA On Site Inspection, thus directly reflecting its mission (and possibly reflecting disillusionment with the "Cloud Gap" program proper); VELA High Altitude, which had combined VELA Sierra and VELA Hotel, was again redivided into those elements, now called VELA Surface and VELA Satellite. The reason for the latter change is unclear, except that it gave increased prominance to the extraordinarily successful satellite program. No new organizational elements were created within VELA during the 1965-66 time period.

In VELA Uniform, ARPA continued to provide support to the Worldwide Seismic Net (despite an increased role by the U. S. Coast and Geodetic Survey); a broad program of basic seismological research continued; one which Herzfeld, like Sproull, believes "changed geology completely," resulting in "modern geology."[37] The shift of emphasis from research on Geneva-type stations to large aperture arrays, begun in 1963-4, was largely complete with LASA construction begun in late 1965; underwater detection research continued; and th nuclear explosion program was carried forward. Among newer programs, development proceeded on an ocean bottom seismograph station (designed for monitoring in coastal areas); a series of chemical explosions off the U. S. coast were conducted using obsolete Navy munitions in order to generate data on seismic wave propogation and attenuation across the United States (the so-called CHASE tests*); and models of an unmanned seismic observatory were developed (a possible adjunct to on-site inspection arrangements).

* CHASE is an acronym for "cut holes and sink 'em;" the munitions and the barge were sunk together for the underwater test.

VELA Surface continued as a relatively small program investigating techniques and devices for detection of atmospheric or high altitude tests. Research included projects in acoustics, magnetotelluric, optical and radio techniques, as well as debris sampling.

The VELA Satellite program continued its success story. Two new satellites were successfully launched in July 1965, joining the two earlier pairs of satellites. As of mid-1966 the original October 1963 satellites were still providing data, showing a life expectancy and reliability far greater than had been envisioned at the beginning of the program. The unexpected performance record of the early satellites had allowed a major stretchout of the program and increased attention to developing more sophisticated devices for the later payloads. The program was, in effect, serving as an interim operational capability beyond its research objectives. By now, however, Dr. Foster was pressing for transfer of the program. Herzfeld resisted, fearing that the Services might not do it right.[38] He also did not want to sacrifice the other ARPA objectives which the VELA launches served, e.g., the payloads had early warning and diagnostic components and piggy-back scientific satellites could be included. Once ARPA lost control, it would also lose these options.

VELA On-Site Inspection continued to investigate various techniques which might assist in an on-site inspection effort, with primary emphasis on gas sampling approaches. In addition, two field exercises were conducted in conjunction with ACDA and USGS.

<u>The Large Aperture Seismic Array (LASA) Program</u>

The Large Aperture Seismic Array (LASA) program was the last major effort undertaken within VELA to lay the technical basis for an international underground test detection system of the type needed to support a comprehensive nuclear test ban agreement. The LASA program was conceived in a time of widespread high level national political interest in signing a comprehensive test ban and became a major element in policy deliberations on that subject. Eventually LASA proved inadequate for this ambitious role and was transformed into a more modest research effort.

The transformation of LASA took place primarily during Dr. Herzfeld's period as ARPA Director and is representative of a much broader change taking place in the VELA program at this time. This change may be described in summary form as a transition from the original VELA mission of providing the technical basis for early development of test detection systems to contribute to a ban on testing, to a separate mission (developed out of "safeguard d" to the Limited Test Treaty Ban) of strengthening national test detection capabilities regardless of the imminence of a comprehensive ban on tests. The VELA program, in other words, gradually became much more integrated into the national nuclear test detection and intelligence establishment and less intimately linked to the course of test ban negotiations. The later change in the VELA office's name to the Nuclear Monitoring Research office reflects this shift, as "monitoring" implicitly suggests a continuation of nuclear testing.

The LASA program grew out of interest in the Ruina period in array technology as a potential technique for dramatically improving seismic detection capabilities over those provided by systems of single seismometers.[39] The British had, at the time, made some interesting suggestions with respect to use of seismic arrays which greatly interested Dr. Ruina and others in the field. As a result of this interest, Ruina established a small but highly significant array program at Lincoln Laboratories (which was later to become one of the two major LASA contractors) and he and Sproull later recruited Dr. Robert Frosch, a noted expert in hydrostatic arrays, to head the VELA program.

Dr. Frosch, who arrived in VELA at the beginning of Dr. Sproull's directorship, was responsible for transforming ARPA's rather diffuse interest in arrays into the LASA program. The LASA design concept was to integrate a very large number of seismic instruments (as many as 500 or more) into a single large array spread over a substantial area. The inputs from these many instruments were to be aggregated through modern data processing and analysis techniques in such a way as to greatly reduce the signal to noise ratio, which had proven a major obstacle to the detection and identification of seismic events at low magnitudes. In addition, it was also felt that large array designs might uncover new identification criteria which simply did not exist for traditional seismic stations. If seismic detection and identification thresholds could be reduced to low enough levels, so that only very small nuclear blasts could hope to escape detection, then the United States might be able to reduce or eliminate its demands for on-site inspection, which had been an insurmountable barrier to signing a comprehensive test ban treaty with the Soviet Union. The objective of Dr. Frosch's LASA concept, which was recognized from the beginning to be a rather expensive undertaking, was to achieve such a critical level of improvement in seismic capabilities. But as he is quoted as having said, "$200 million isn't important if it leads to a breakthrough in the arms race."[40]

The initial effort in the LASA program was the development of a research array in Montana. This array, which was well underway in late 1964 and was dedicated by President Lyndon Johnson in October 1965, was to be the largest and most fully developed LASA-type array ever built. At the time, however, the Montana array appeared to be just the beginning. Sometime in late 1964, Secretary McNamara was briefed on the concept and apparently regarded its potential for an international system underlying a test ban to be so great that he ordered planning for a worldwide net to proceed. He did this well before any results had been obtained from the Montana station. This decision was enthusiastically supported by those agencies oriented positively toward aggressive action on arms control, namely, State, ACDA, the Assistant Secretary of Defense for International Security Affairs, and others. Dr. Brown, then DDR&E, was also positively inclined.

Sproull, who was ARPA director during this period, said that he was very keen on the LASA concept, but most uncertain about the advisability then of investing hundreds of millions in building LASA stations around the world. He characterizes McNamara's reaction as much the same as his own:[41]

> The ARPA position ... was kind of neutral. We were proposing a program and designing it but as far as really pushing it 'all out' is concerned, I think we had a kind of an 'on the one hand this, on the one hand that' point of view.... Maybe LASA wasn't the answer because one didn't know enough yet about the way discrimination was ultimately going to be done.... So the ARPA position I guess was that we wanted to do this, but it was not a position that ARPA was pushing very hard, and 'do it at all costs' and 'you're crazy if you don't' and so on and so forth. It was more I think a position that said somebody ought to be a spokesman for this and makes sure that it gets a fair trial and gets pushed all the way to the Secretary's office. The Secretary was interested. But realize that when you get into hundreds of millions of dollars it had to compete with lots of other programs and it also had these problems of the host governments (which god knows ARPA was very alert to, through AGILE and through [the] worldwide network of 125 seismic stations).

The LASA concept, and particularly the notion that it be developed rapidly into an international detection system, also had its strong opponents. Not surprisingly, the AEC and Joint Chiefs were known to be critical and urged a cautious approach. The most serious criticism of LASA, however, came from seismic experts associated with the U. S. operational nuclear test detection system.[42] An international LASA network would, of course, have been somewhat competitive with national capabilities, and one might also argue that those associated with the latter inevitably would be more sensitive to national security arguments for continued testing and more skeptical of the need for a rapid move toward a test ban. The conservative view from this source, however, was reinforced by a number of sound technical arguments. Building a full-blown facility in Montana was an expensive way to determine the feasibility of large arrays; moreover, commitment to an international system before research results were in (from the Montana facility and elsewhere) involved very high technical risk and was arguably premature.

Despite opposition to LASA, and especially to a world-wide LASA network, momentum during the first half of Dr. Herzfeld's tenure as ARPA Director was clearly toward commitment to this program. Just after the President dedicated the Montana array in late 1965 -- and still before any considerable amount of data had been analyzed -- McNamara made a preliminary decision to proceed with FY 1967 funding of the plans for a full system of 10-12 stations. In the meantime, planning for the location of foreign stations was underway.

McNamara's late-1965 decision proved, however, to be the peak of the LASA program. Commitment to a large system was immediately and effectively attacked on technical grounds, primarily on grounds that results from the Montana array had not been produced and analyzed so as to establish that the system could meet hoped-for performance levels. As a result of this attack, McNamara reversed his decision and the program continued in the research mode pending later decisions. In the fall of 1966, an external-to-ARPA technical evaluation of the Montana LASA concluded that the array did not meet optimistic earlier projections with respect to reductions in signal-to-noise ratios, that no fundamental breakthroughs in identification techniques had been uncovered, and that a network of smaller, more traditional stations would be equally or more effective than a LASA network and at much reduced cost. This technical assessment is widely believed to have killed LASA as an international system around which a test ban might be concluded.

At the same time that more conservative judgments on LASA capabilities were beginning to appear, political pressure for a test ban began to dissipate. The test ban enthusiasm of the Kennedy Administration had begun to wane later in the Johnson period; McNamara was encountering even more difficult problems in managing the DOD with the expansion of the Vietnam conflict and was increasingly occupied with these concerns; Foster, the new DDR&E, was not a supporter of major test ban initiatives. Perhaps most important, 1966 was a crossroads in the development of strategic weaponry, and a key feature of the next generation of strategic missiles was to be the development of small multiple warheads. Development of this technology, deemed essential to upgrading deterrent capabilities, required an extensive commitment to underground testing. By the end of 1966 the drive for a comprehensive test ban had essentially ceased to exist as a matter of national priority.

Thus toward the end of Dr. Herzfeld's tenure, LASA had died as a revolutionary nuclear test detection system. Though the decisive critique of the LASA system had suggested an alternative approach, it was not pursued, due both to the decreased priority of achieving a comprehensive ban and to the fact that the alternative system did not have the potential for a revolutionary breakthrough in capabilities that LASA was once expected to have. In this context, the Montana LASA was gradually reoriented toward more evolutionary, incremental research objectives. In early 1967 a second large array, NORSAR (located in Norway) was added as a research device. In 1968 a new research emphasis was added, namely, investigation of "long period" seismic signals (LASA was designed to improve detection/identification of "short period" signals) and a new large array (called ALPA) was built in Alaska. In many ways the new effort was technically richer and more balanced than its predecessors, but despite the existence of some strong enthusiasts for its potentialities it did not offer such revolutionary promise.

In retrospect, LASA made numerous contributions to the science of seismology and to the technology of nuclear test detection. Of major importance, for example, has been the introduction of modern data processing techniques into seismology on a large scale. A great deal was learned about the limits and applications of array technology, much of which has been incorporated into ongoing national systems. On the other hand, the Montana LASA and to a lesser extent the later large arrays were rather expensive and, like a number of other large "facility" investments, have posed continuing burdens on the ARPA budget, perhaps beyond the point where ARPA support might logically have been terminated. To one observer, who advocated a more evolutionary step-by-step approach to investigating large array technology, the Montana-LASA was far over-designed and represented a tendency for scientists "to build monuments that will endure after them."[43] LASA may perhaps be regarded as a high-risk undertaking which would have had enormous impact if totally successful, i.e., underwriting a comprehensive test ban, and which still had substantial technological impact while failing in its main objective. A conservative approach might have been more cost effective, but would not have satisfied contemporary demands to reach for a breakthrough. This responsiveness (unless the prospects for a LASA breakthrough are viewed as unreasonable from the beginning) has to be traded off against a more narrow cost benefit accounting.

AGILE

Expansion of Project AGILE continued during Dr. Herzfeld's period as Director. This is hardly surprising inasmuch as he was convinced intellectually that AGILE was addressed to significant issues and could be made to succeed. One of the reasons that Herzfeld had originally decided to join ARPA was Godel's compelling description of the insurgency-counterinsurgency problem.[44] Unlike Ruina and Sproull, Herzfeld found AGILE an attractive challenge.

In budgetary terms, AGILE reached a peak of around $30 million for both FY 1965 and FY 1966. About half the size of the VELA program, it remained the third largest program in ARPA. The program had tripled in funding by its forth year of operation.

The continued broadening of AGILE functions is perhaps of even greater interest. Far from its initial charter to support two Southeast Asia field offices in research of value to indigenous forces, AGILE by 1966 is described as a very broad, comprehensive research attack on virtually all aspects of the insurgency-counterinsurgency problem. The introductory paragraph to the AGILE section of ARPA's FY 1966 Annual Report is illustrative:[45]

> Project AGILE research and development continues to be responsive, on a quick-reaction basis, to the critical technological problems of remote area conflict. Concurrently, there is an increasing emphasis on the definition and understanding of the environmental and behavioral factors which have a fundamental and perhaps dominant importance in insurgent conflict. Recognition of the close interrelation between the technological, behavioral, and environmental factors has resulted in the initiation of an integrated, functionally-oriented systems approach to the total solution of the problem of counterinsurgent operations. (Underline added.)

The statement of AGILE's role as seeking the "total solution" to counterinsurgency problems could hardly be more ambitious, and is a considerable expansion of AGILE's mission beyond that of the Sproull period. Ruina's AGILE emphasized "quick-fix" hardware modifications. The AGILE of the Sproull era gave impetus to longer-term research (particularly environmental) in an attempt to make AGILE more scientific, and to geographic expansion beyond Southeast Asia. Herzfeld's AGILE reaches further toward a broad "system's approach" and even higher levels of sophistication. Also notable in the FY 1966 statement is the fact that mention of support to "indigenous forces" as a major program focal point is dropped. This important omission came, of course, at a time when U. S. forces in Vietnam were being vastly expanded, and the implication is that AGILE will become supportive of this effort. This is confirmed in Dr. Herzfeld's FY 1967 House Appropriations Committee testimony when he notes that AGILE has "picked up some of the problems which arise for American troops."[46] Nonetheless

ARPA believed that the indigenous forces support role was the one it should be filling, as much as possible.

Another very interesting aspect of the FY 1966 statement is that AGILE clearly claims for itself the highly visible role of a gadfly and "catalyst" vis-a-vis the Services, and rather directly implies that the Services are derelict in giving sufficient or timely attention to critical counterinsurgency problems. The FY 1966 Annual Report states, for example:[47]

> The AGILE Program is designed to act as a catalyst. That is, it provides a capability for rapid response to critical problems requiring immediate attention until one of the Services is able to address itself to the problem. As soon as Service interest and responsibility is assigned to a remote area conflict problem, ARPA activities are reduced or terminated, except in those cases where continued ARPA support is desirable or requested.

That ARPA viewed AGILE as filling real gaps in Service capabilities in the counterinsurgency field is well illustrated by a vigorous exchange between Herzfeld and Congressman Minshall during the FY 1967 House Appropriations Committee Hearings. Dr. Herzfeld was defending AGILE sponsorship of contractor interviews of Viet Cong prisoners, which the Congressman felt was the proper function of military interrogation teams:[48]

> Mr. Minshall: This is nothing new. We had military people doing it in World War II who were experts in this field. We didn't need a bunch of civilians to do the job that the military and others in Government are already trained to do.
> Dr. Herzfeld: This war is a war which turns on how guerrillas fight against a government and how that government fights against guerrilla operations. It is a different kind of war and the kinds of questions that arise are different.
> Mr. Minshall: One of the reasons is that we had a lot more military. If we are going to fight this war with contract civilians we are in real trouble.
> Dr. Herzfeld: I don't think it is that simple. The average military system really is not very well geared to worrying about some of these interfaces between the civilian and military.

The broad AGILE program which had evolved by 1966 consisted of the following program elements: (1) field research units -- now including offices in Saigon, Bangkok, Beirut and Panama, and a liaison office in Singapore; (2) environmental research -- conducted primarily in Thailand and Panama, with various supporting studies in the U. S.; (3) operations analysis studies -- including studies of forest and swamp warfare, guerrilla safe havens, route security, highway and rail systems, etc.; (4) applied behavioral research -- including studies of Viet Cong motivation and morale, hill tribes, etc.; (5) advanced technology -- divided into the categories of weapons technology, surveillance technology, mobility, communications, and biomedical research; and (6) systems integration -- focusing largely upon linking together a "counterinsurgency system" for Thailand.

By 1966, AGILE work ranged from Viet Cong prisoner interviews to studies of nutrition in Nigeria; from collection of data on radio propagation in tropical environments to development of a "jet flying belt" to propel an individual soldier; from testing the mobility of specific vehicles to studying group structure in Montaguard villages; from evaluating Thai rural development programs to collecting data on climate, soils and micro-biological life in Panama.

While critics have sometimes argued that AGILE suffered over the years from an unclear set of objectives, it is probably fairer to say that events inevitably distorted its original concern with indigenous forces such that it became increasingly involved with a mixture of activity, some of which was allegedly intended for them and some for U. S. forces and some for both. Internally, at least, ARPA personnel usually were clear about what the objective was, even if they were not reaching it. Herzfeld's recollection of how AGILE evolved from the time he joined ARPA is instructive.[49]

> [T]hat had to do mostly with helping the indigenous forces and with helping the indigenous populations, based on the assumption that counterinsurgency is not primarily a military problem anyway. It was primarily a political beliefs and social problem.... When I got to be Deputy Director that was still the format of AGILE. And I remember pretty vividly thinking about the question 'how this can be used or whether it can be used for helping U. S. forces?' [In 1963] it was not at all clear to any of us, and certainly not to me, whether this AGILE could be used to help the U. S. military, and of course at that time there were no significant U. S. combat forces in Southeast Asia. So the

> concentration was all on the indigenous help; hence the logic of the local laboratories to build up local capability in Vietnam first and then Thailand -- and we were also thinking of other places like Iran -- local capabilities for local use by local people. Now when U. S. combat troops got into the theatre, that changed some, in the sense that a considerable premium was put on also helping U. S. combat forces. Then, gradually ... when U. S. combat forces first went into Vietnam in any numbers, [there] was a gradual shift of emphasis more and more in the direction of helping U. S. forces which, I think, in part, was everybody's attempt -- including mine -- for being useful with the war, which was obviously considered a very key item, together with the conviction that in Vietnam in those years more and more of the fighting role went to the U. S. forces and less to Vietnamese forces.

Herzfeld was not enthusiastic about this turn of events. He did not like mixing into what was becoming a more conventional shooting war in many respects:[50]

> [T]hat was why I was so interested in the Thai effort because, to my mind, that was more like what AGILE really should be doing, whereas what we were doing in Vietnam was more like what any quick reaction capability of the Services was doing. And the main difference was that we were even quicker than quick. And, also, a lot of our stuff was technically more sophisticated and sometimes superior, technically, because we could get good people faster.

On the other hand, the DDR&E, reflecting tremendous pressures on him to use RDT&E resources to help win the war, soon, was most interested in having AGILE make contributions to U. S. combat success. According to Herzfeld, Foster was negative about AGILE "unless it produced something elegant for the U. S. forces, in which case he was very positive."[51] ARPA tried to accommodate that interest by standing ready to spend funds as a quick reaction basis for requests from General Westmoreland and the science advisers that the DDR&E assigned to his staff. Foster and Herzfeld held a weekly cryptologically secure conference call with them via the so-called ZAP channel. Herzfeld said that he "pledged that we would offer quick reaction capability to whoever was at the other end." [52] Roughly $5 million of AGILE money per year was left free for that purpose plus a sizeable amount of the Advanced Sensors budget. Herzfeld particularly feels that ARPA measurements work on night vision and target identification was excellent:[53]

> They were among the earliest good measurements and many more have since been made. And I think it started a very serious tradition of doing that kind of thing right [in the Services, who picked it up from being the ARPA agents initially].

Nonetheless Foster's use of ARPA's quick reaction capability to do short-term gadgetering led old timers within the Agency, and some of its 'old boys' outside, to lament disparagingly that ARPA had been reduced to being "Johnny's hobby shop." Occasionally these differences of opinion spilled out in public. Herzfeld even appealed a bit to the Congress for protection against unwarranted raids on ARPA resources, doubtless aggravating the Secretary, the DDR&E and others. In doing so, however, he was reflecting a viewpoint deeply held by many in ARPA. The powerful Congressman George Mahon, for instance, asked if ARPA's role of doing exploratory development of "far-out" technologies was not being sacrificed to the exigencies of the moment (namely, quick-fixes for Vietnam). The meaning of Herzfeld's response was clear:[54]

> I am delighted that you raised the point. It is one which concerns us constantly.... I think we need the help of your committee in doing this. We are always under considerable pressure from all kinds of people, including sometimes this committee, to answer: "Why are you doing this? Does this make any sense at all?" Questions like this, sir, are very proper and very sensible questions, but the effect of questions like this is to make it less likely that far out things will get tried.
>
> So I think we need the support of this committee to continue this particular function, and I am delighted with the encouragement which I read from your question. There are great pressures on us to do the things that need to be done right away. One of the things that ARPA can do is to react more rapidly than the military departments. It only really takes the three of us here in ARPA to make a decision. If we decide that something has to get done and Mr. Beard assures me that the money is available and that we would not be breaking regulations by doing so, we can sign

> an ARPA order and get it out into the field in an hour, if necessary. There is no other organization in Washington that I know that can do that.
>
> As a consequence, we are under considerable pressure sometimes to help with this, help with that, so on, because we can react rapidly and when an emergency arises, "OK, ARPA, you do it, you are master." I think that is sometimes a misuse of ARPA; not always. I certainly would be the last to say that we shouldn't go out and help General Westmoreland on problems such as this tunnel detection business. I think that is very important. If we wouldn't do that, we would be shirking our duty. But it is a different mode of operating.

On balance AGILE was rapidly becoming a millstone around ARPA's neck. McNamara showed little or no interest, except in the previously mentioned series of Viet Cong prisoner interrogation reports and analyses undertaken by a small RAND team. Herzfeld regrets, in retrospect, not trying to present ARPA's view of counterinsurgency more directly to McNamara, in contrast to the military view: "We thought there were subtle ways of fighting, [but] the American style of fighting is you level everything with bombs and then you go in."[55]

The Deputy Secretary was especially hostile to AGILE, perhaps to ARPA as a whole. Sproull and Herzfeld both found him highly critical. Vance had been Secretary of the Army. McNamara and Brown had used ARPA and ARPA programs as a lever against his and the Army's views on BMD. The AR-15 episode, of course, had infuriated the Army. All the Services resented ARPA as an intruder, in a roles and missions context, once they became interested in Vietnam, and the Deputy Secretary heard all the complaints. Herzfeld has summarized that situation accurately, using the ARPA advanced sensors projects as a case in point:[56]

> As U. S. combat forces became involved in Vietnam ... eventually we got into roles and missions arguments because it looked like the two [ARPA and the Services] were doing the same thing and they occasionally were very close. Sometimes even exactly the same.

The Deputy Secretary was also responsible for leading the serious fight within DOD to economize on both people and funds. ARPA's field units were visible and hence highly vulnerable targets. The number of personnel in them looked large, especially in comparison with headquarters. "So that" Herzfeld said, "was a whole dimension which was constant agony."[57] Vance also was in charge of countering press criticism of the Johnson Administration's conduct of the war. Reflecting its great sensitivity on that point, he rigorously pursued the truth behind stories of alleged stupidity or worse.[58]

> It was assumed in his office always that it was ARPA's fault and we often spent many, many days chasing something down to find out if it was the Army's, the Air Force's or the State Department's or somebody [else's].... ARPA [often] had nothing to do with it. So we spent a great deal of time on that.

AGILE, of course, gradually came under increasing attack on the Hill for duplicating Service work, interfering in Service roles and missions, engaging in unsuitable research, serving as an illicit and costly surrogate for the Military Assistance Program, etc. The Deputy Secretary, regardless of the validity of the charges, could be certain of one thing: ARPA was once again a source of aggravation for him and for the Department.

Herzfeld recalls being a somewhat lonely figure defending AGILE's programs and outlook:[59]

> We had very few supporters. It was achieved, I think, mostly in the teeth of the system. I cannot think of a single person in OSD, in the two years I was Director, who welcomed the discussion of AGILE on _my_ terms. Most of them wanted to have a discussion on AGILE with me on _their_ terms -- how to kill the [deletion] thing -- but on my terms, how to make it bigger, better, and more successful, very few people had time for that.

It was a valiant effort. Herzfeld's dedication to the validity of the basic shape of the problem envisioned by Godel is praiseworthy. Where he ultimately went astray, aside from the overwhelming force of events in Vietnam over which nobody in ARPA had control, was in his choice of "solution" (discussed in detail in Chapter VIII) that is an assessment, however, that applies to virtually every man who sought to grapple with insurgency.

Substantively, the AGILE program had immense difficulties. It was competing directly with the Services on hardware modification projects intended primarily for U. S. troops. It was conducting environmental research projects in Thailand and elsewhere that either seemed to be producing no results or irrelevant (to Vietnam) results. It was promising a comprehensive "systems" solution to classic insurgency situations, but that too was increasingly irrelevant to Vietnam as the war there escalated to quasi-conventional levels of conflict. More serious, the systems scheme had a ring of phoniness to it which ultimately proved to be its undoing. It was to become an exceedingly expensive failure during the Rechtin period, and there are plenty of people around to say "I told you so."

Materials Sciences

The Materials Sciences Program of the Herzfeld period retained essentially the character of Dr. Sproull's program. The IDL's continued to be by far the largest component of an office budget now reaching an annual funding level of $28 million; the coupling program initiated by Sproull was well underway, with four major contracts being supported; the materials preparation program also continued, but the initial focus on crystal growth (an activity now adequately covered by the IDL's and other institutions) was phased out in favor of new programs in beryllium research and the development of a research facility concerned with magnets and related materials.

The emphasis of the 1965-1967 materials program thus continued to be largely focussed on university basic research programs. Though the coupling projects were aimed at militarily relevant problems and, to cite one example, a major part of the beryllium program was conducted in a Service laboratory, program statements of the period give no more -- and perhaps less -- attention to military relevance than statements of the Sproull period. For example, they indicate only that the materials developed permit "a wide variety of uses by the Defense Department" or are of "great interest."[60] There is little stress on specific projects of direct application to concrete military requirements.

The IDL program was still viewed largely in terms of the institution-building objectives set when the effort was initiated in 1959. This is well illustrated by an internal review of the IDL program completed by ARPA in August 1966.[61] The review focussed on indicators that would demonstrate that the IDL program had produced both quantitive and qualitative improvements in basic materials research on campus. Probably the clearest indicator of program success at that time was the obviously direct effect of the IDL's on production of trained manpower in the materials sciences. The quantitative goal set by the Federal Council, it will be recalled, was a 75 per cent increase in the number of materials Ph.D's. While by 1965-1966 this Ph.D increase had not yet been fully achieved -- most of the IDL's were not fully operational until 1963 or later and there was an obvious lag time before the educational system could complete a large increase in Ph.D's produced -- graduate student figures indicated that the IDL's were well on the way toward accomplishing this goal. The ARPA review figures show graduate student-research assistants in materials fields increasing from approximately 1100 in 1961-62 to 2000 in 1965-66, an 82 per cent increase. ARPA-supported graduate students alone accounted for some 600 of the addition.[62] Another compilation produced at about the same time by an ARPA staff member showed an increase of materials faculty and post-doctoral staff at the 12 IDL shcools from approximately 350 to 550, a 57 per cent increase.[63] Projections showed continued increases through 1969-1970. While calculating the exact percentage increase in total U.S. materials Ph.D's attributable to the ARPA (and other) IDL programs would no doubt be difficult, it seems clear that the ARPA program's contribution was very significant, well in keeping with the objective initially set for it.

Other contributions identified were the extensive development of central facilities with appropriate research equipment and an attendant improvement in the quality and scope of research which could be conducted in the university environment. The review credits the IDL's with greatly improving the competitive position of the universities vis-a-vis industrial and government laboratories in terms of the sophistication of research efforts which could be conducted. Though this cannot be easily quantified, the 1966 review and other documentation on the IDL's appear to be highly convincing on this point. In short, the ARPA IDL's appeared by the mid-60's to have made a very substantial improvement in the university materials research infrastructure, which in turn permitted more advanced research to go forward.

Finally, the 1966 review makes a reasonably convincing case on the positive impact of the program's interdisciplinary focus. It notes, however, that impact here had probably been less uniform than in the above cases. On the positive side, the review credits the IDL's with a definite impact in broadening the field of chemistry through the unfusion of physics problems and concepts (and heightening interest in crystals) and in significantly strengthening the field of metallurgy which is especially dependent on interdisciplinary cross-fertilization. Joint appointments and co-location of multi-disciplinary staffs were two saluatory effects of the IDL program cited by the review as fostering cross-disciplinary exchanges. Incidentally, these IDL approaches were said to have been widely copied at other non-IDL universities.*

The review also assessed each of the twelve IDL's funded by ARPA, the results of which are presented here only in summary form. In brief, seven of the twelve schools were felt to have excellent programs; three to have good programs but with some major current or latent problems requiring action; and only two were said to have "serious shortcomings

* The Lehigh and McMaster programs, for example, were separately cited by Sproull as attempting "almost literal copies."

which put the future of funding at the university in some doubt."[64] One of the programs was deemed unsuccessful because of a strongly anti-interdisciplinary tradition in the university, compounded by poor leadership quality and high leadership turnover in the IDL. The other case was judged unsuccessful for lack of interdisciplinary exchange, attributed more to weak university administration rather than a hostile tradition, and weakness in one faculty area. Both had failed to establish truly central facilities as envisioned in the program. Both, however, were also credited with having some very strong individual areas which had benefitted from IDL support. In summary, despite problems in individual laboratories, the IDL program appeared to enjoy a high measure of success during Dr. Herzfeld's tenure.

The assessment criteria used by ARPA were essentially all in the nature of numerical increases in graduate students and of enhancing basic infrastructure capabilities and institution-building. The terms of reference under which the IDL program was assessed elsewhere within the Department of Defense were shifting, however, and the institution-building rationale did not serve to protect the program from criticism.

By 1966 (virtually at the same time that the favorable internal IDL review was produced) the position of the program was becoming tenuous. To illustrate, the official responsible for reviewing the program in DDR&E was said to have taken the position: "Either orient the IDL program to Defense Department needs or transfer it to NSF."[65] While the Materials Office staff and Dr. Herzfeld obviously felt that the IDL program already was relevant to DOD needs, they were obliged to concede that some reorientation to more applied problems could take place without destroying the program. In late 1966 and early 1967, therefore, an exchange of memoranda with the responisble ODDR&E official took place with a view to defining more applied, "military-relevant" tasks that the IDL's could undertake. That this exchange took place with some misgiving, however, is illustrated by the following:[66]

> I would like to end on two cautionary notes. I do not believe that the universities should ever be expected to make the kind of contribution we can only obtain from government laboratories. I am speaking here of the R&D interface with military field operations and planning and with military engineering. If we ask the universities to participate in any major way in the function of coupling applied science to military problems, we shall find them to be inefficient, and simply unable to be practical. The universities are, of course, rich sources of consultants on those problems, but that is a different matter. My second point is that there is a major trend in industry at present in the materials field to pull

> out of the forefront of basic research. I believe the DOD has a fundamental interest in the health of the basic research community, and to the extent that we do, we should be insistent that the universities reemphasize their role as the major source of basic research in the country, and not encourage them to follow the industrial trend.

By early 1967, however, it was becoming clear that the ARPA Materials Office's position that strong DOD support for the IDL's should continue might not carry the argument. The major problem area appeared to be the DDR&E's disenchantment with the concept of broad institutional support for materials research, which was reinforced both by the other problems that DDR&E had with the ARPA program (noted earlier) and by increased Congressional hostility to broad Defense involvement in basic university research programs.

Just as Herzfeld departed ARPA, the vulnerability of the IDL program was clearly exposed by the Fiscal Year 1968 slash in the Materials Office budget, from $27.3 million in FY 1967 to $4.4 million in FY 1968. At the time, this was stated to be a one-time DDR&E response to Vietnam budget pressures and it was accomplished simply by cutting forward funding to universities by one year, i.e., moving from three to two years of advance funding. The next year's budget (FY 1969) was supposed to accommodate a return to previous funding levels. In fact, however, this "one-time" cut was the beginning of the end of DOD support for the IDL program. Dr. Rechtin, the next permanent Director, shared the DDR&E's objections to the program. In fact, he considered it a symbol of all that was wrong with ARPA. As will be discussed later, the remaining forward funding years were progressively cut back to one year and new budgetary support never returned to anything like former levels.

In the meantime, the other major materials program -- the "coupling" work -- was also beginning to encounter problems. The four contracts, ranging from $450 thousand to over $1 million in annual support, had some notable technical successes, but a subsequent evaluation was generally negative in its overall assessment.[67] Problems noted included difficulties in linking basic university research to the applied goals of the projects, problems in interdisciplinary communication across participating institutions, lack of specificity in technical goals, and numerous management difficulties. The latter were serious: "In no case do we now have clearly successful management."[68] In the retrospective view of a former head of the ARPA materials office, many of the concepts involved in the coupling program were excellent, but the projects undertaken were not cost effective and probably were overly ambitious, especially the idea of creating broad problem-oriented centers of excellence "of worldwide renown," drawing on multiple institutions. Sproull agrees that the coupling program did not work out and cites a number of practical reasons: the generally rough period ARPA went through in 1965-1966; the evolving over supply of Ph.D's in materials; and the fact that the program was "battered at by ants," meaning a succession of small problems, mediocre contractors and the absence of strong-willed people with an interest to try something new.[69] In any event, doubts were beginning to crop up vis-a-vis the coupling program in the latter part of Herzfeld's period which reinforced the problem image created by the IDL situation.

The stage was thus set for a major program reorientation on Dr. Rechtin's arrival.

Information Processing Technology

During the Herzfeld period, the information processing technology program continued to be a strong and relatively noncontroversial effort, still predominantly oriented toward basic and applied research. The program was, however, shifting gradually toward "6.2" development efforts, as suggested by three undertakings: development of a second generation time-sharing computer system (MULTICS) at MIT, commitment to build an immense parallel processing computer (ILLIAC IV), and initial investigation of means of interconnecting or "networking" geographically separate computers (ultimately crystalizing into the ARPA Network or ARPANET project). In retrospect, the IPT office during the 1965-1966 time period appears to be in a transitional state between the research emphasis of the Ruina-Sproull period and the exploratory development orientation of the Rechtin-Lukasik years.

Interestingly, the gradually increasing emphasis on defense relevance which had began to effect the other research-oriented offices appears not to have affected IPT to nearly the same extent. Broad-based computer research simply was accepted as relevant on its face. ARPA's description of the FY 1966 IPT program, for example, justified the program on [redacted] technology rather than stressing any unique military applications. In fact, it was boldly asserted that DOD was a beneficiary of the research largely in a secondary sense, that is, IPT's work would improve the quality of products of commercial manufacturers and DOD would ultimately benefit as a buyer of such products:[70]

> The Department of Defense utilizes more than two-thirds of the Federal Government's computing resources. The ARPA Information Processing Techniques Project is directed toward creating techniques, languages and procedures in the use of the electronic computer to do a better job. This project has been directly responsible for the development of multiple access, time-shared computer

> systems. The first of such systems to be made available to the public are being marketed this year by the commercial manufacturers. This new way of using computers allows an individual with a problem to use the computer in a conversational, interactive way, thereby permitting new approaches to solving a variety of problems that heretofore were not amenable to the computer. This part of the ARPA program has demonstrated that a single computer system can serve dozens of human users concurrently such that each user has at his continuous command the resources of the entire computer. The economic payoff of this research is obvious.

The point here is that the revolutionary impact of rapid developments in the computer field in the mid-1960's were so obvious that very broad criteria of Defense relevance were still acceptable.

During this period, the IPT program tended to maintain the university focus established by Dr. Licklider, who had now left ARPA and was succeeded as IPT director first by Dr. Ivan Sutherland and subsequently by Mr. Robert Taylor. Project MAC retained its position as the largest and most visible of the university efforts, though major projects were underway at numerous other institutions. Even the primary new "hardware" development program of the period -- the ILLIAC IV computer -- was supported through a university, the University of Illinois.

The MAC program, as noted above, was highly colored by the development of the MULTICS advanced time-sharing system, though a very wide-ranging research program was actually supported. MULTICS itself was a subject of some controversy throughout the period and into the late 1960's, as the system proved more costly than anticipated and encountered numerous delays before going into operation.[71] Dr. Licklider, who later became director of Project MAC, attributes these problems to the machine being "over-designed," due partially to the constant flow of very advanced concepts from the MIT community, and admits that MULTICS came close to becoming a fiasco.[72] It emerged, however, as the most-sophisticated and "in many ways the best" operational time-sharing system in existence and is now being sold commercially by Honeywell. MULTICS is also perhaps the only operational time-sharing system which could be modified to meet military secuirty requirements, an issue which has come to be of increased interest to DOD and IPT in recent years. Despite early difficulties, therefore, MULTICS is now considered one of IPT's success stories, though with not quite the impact of the first MIT time-sharing system.

Extensive research was supported during the Herzfeld period on advanced programming and computer languages. ARPA, for example, underwrote the development of "higher level" computer languages such as LISP and Formula ALGOL, which enable the compter to address problems which could not be solved by the traditional FORTRAN and COBOL languages. Computer graphics (a special interest of Dr. Sutherland, who was a prominant innovator in this field) also received considerable emphasis during the mid-1960's. The IPT program produced a very long list of highly technical software developments which cannot be meaningfully described here, but which have had lasting impact on advanced computer technology. According to one MIT computer scientist (an acknowledged leader in advanced computer technology in this country), the ARPA projects in this and subsequent periods "probably contributed more than all the other computer science laboratories in the country in the most advanced things ... it's almost impossible to think of anything important that has happened anywhere else."[73]

Initiation of ILLIAC IV. While Herzfeld sustained the thrust of earlier information processing work, highlighted by work on the second-generation MAC time-sharing system, the IPT program also moved in new directions. Notable among these initiatives was the development of a program in "parallel processing" which was to prove one of ARPA's more controversial endeavors.

Illustrating that ARPA still retained responsiveness to outside ideas, the parallel processing effort was initiated on the basis of an unsolicited proposal, "Experimentation in Parallel Computation," submitted to ARPA by Dr. D. L. Slotnick in October 1965.[74] Dr. Slotnick was an innovative computer scientist at the University of Illinois who was associated with the design of unique computer architectures. His proposal to ARPA involved the concept of linking several arithmetic computer processors to a single control unit (rather than the traditional one-on-one architecture), designed so that the arithmetic processors could work on parts of a calculation simultaneously or "in parallel." By enabling several functions to be performed concurrently rather than sequentially it was argued that the power and speed of the computer could be increased dramatically. The concept, however, was highly controversial on several grounds: the feasibility of developing the required hardware and achieving high levels of reliability with it, the complexity of the required programs, and the existence of a sufficiently large class of problems suitable to parallel computation to make such a machine development worthwhile.

To support Dr. Slotnick's proposal was thus something of a "high risk" proposition, given the doubts of many contemporary experts. It also entailed a substantial investment to design and build a prototype machine. Should the concept prove out, however, there would also be high payoff because the computer development program eventually approved promised an increase in "speed of data processing from 500 to 700 times over present computers, and over 100 times faster than any computer known to be in development."[75]

ARPA's speed in acting on this program is indeed impressive. On October 15, 1965, eight days after the formal proposal was submitted, a program plan was developed. One week later an ARPA Order to initiate the program was signed, with the Rome Air Development Center as agent. In January 1966 the University of Illinois requested bids from industry to investigate the feasibility of developing the machine's architecture. The Illinois contract with ARPA, which was designed to develop hardware design criteria, software and languages, became effective in April. Three industry contractors (RCA, Burroughs and UNIVAC) were selected at about the same time to provide inputs on machine design. By the end of the year this "Phase 1" effort had progressed to the point where the three industrial contractors were asked to submit detailed proposals for machine development. Burroughs was awarded the construction contract in January 1967, with total program cost estimated at $21 million. In just over a year the parallel processing effort had moved from an unsolicited concept paper through a preliminary design phase to commitment to a multi-million dollar hardware development project. ARPA had clearly not lost its flexibility and ability to take initiatives.

Behavioral Sciences

The ARPA behavioral sciences program in the Herzfeld period consisted of five major project areas -- teaching and learning (primarily computer-aided instruction); human performance (including research on psychological factors relating to memory, hearing, and response to pain); human communication (with emphasis on cross-cultural communication); bargaining and negotiation (including gaming and simulation of international conflict); and behavioral science process and theory (primarily studies of cultural and social change).

What is perhaps most interesting about the behavioral science effort in this period (roughly a $4 million annual program) was that it managed to sustain a significant social science research effort concerning foreign cultures during a time of very unfavorable conditions. The so-called "Camelot" episode, mentioned above, occurred in June 1965. Camelot was to have been a large Army-sponsored study of internal conflict, with case studies in a number of developing countries around the world. When a questionably conducted consultant's visit to Chile raised a political furor in that country and the U. S. the project was cancelled, a storm of academic protest arose over Defense sponsorship of social science research and laborious clearance processes were put into effect for those behavioral science projects which were continued abroad. The Camelot episode also served to reinforce traditional State Department prejudices, namely, tending to rely upon the accumulated experience of foreign service officers as the source of knowledge on a foreign culture. Beyond this, the Camelot episode brought Defense Department research efforts in behavioral science under much closer Congressional scrutiny. Congressional questioning was also increased due to behavioral science research being performed in the Vietnam context, including ARPA projects undertaken as part of the AGILE program.

Despite the unfavorable environment, the Behavioral Sciences office was able, throughout the mid-sixties, to maintain a significant program of research relating to foreign cultures. Post-Camelot initiatives involving research in sensitive foreign countries were undertaken -- e.g., a study undertaken by Kalamazoo College in Peru. The new project clearance requirements were followed (necessitating, for example, State Department and U. S. Embassy approvals) and other steps were taken to reduce possible tensions arising from such research. The ARPA program insisted on certain standards: unclassified basic research, explicit acknowledgement by the researcher of DOD funding, host nation government approval of the project, a host national university project co-director, publication of all results in the open literature in both languages, and if possible provision for the host nation co-director to be present in the U. S. for the period when results were written up. Some of the more sensitive aspects of field research, such as attempts to forecast governmental stability, were never considered legitimate subjects of inquiry in the program. ARPA also was eager to have U. S. universities accept greater responsibility for the behavior of their researchers while in the field, but this was hard to achieve. I[illegible] as a model set of principles for government support of foreign area research.

What apparently kept this line of research going in the face of new constraints and criticisms was the aforementioned deeply held belief of the Behavioral Science office director, and others in ARPA and OSD, that the U. S. military was being thrust into a variety of involvements with foreign societies, and that research could be of value in improving understanding of them -- perhaps to the extent of enabling the military to fulfill its assigned roles more effectively. There was an underlying feeling that the military had not sought these overseas roles but rather was at the mercy of foreign policy decisions made elsewhere, and developing an improved base of knowledge on foreign cultures was almost viewed as a form of self-protection. Dr. Foster was publicly a strong defender of a research effort on foreign cultural and social factors, and supported such programs in the face of increasing Congressional opposition well into the late 1960's. In May 1968, for example, he still argued the case made during the Herzfeld period:[76]

> We are interested only in those so-called cultural and social factors that have a clear relationship to Defense activities. Today this spans a great range because the Defense Department shares responsibility for many international activities.

> In the last decade, U. S. forces have been involved -- at quite different levels -- in conflicts in Lebanon, the Dominican Republic, and Vietnam. No matter what one's view of these incidents, DOD research must help provide some understanding of the limits on the effectiveness of various military options in situations in which we consider the use of military force.
>
> There are many concrete reasons for this research. Some military personnel are in continuous, close contact with foreign leaders and with foreign military and civilian populations. These contacts include participation in negotiations (e.g., Korea); training and advisory activities in the U. S. and abroad; and civic action programs in several regions of the world. Defense personnel, as well as all other Americans officially involved, must understand the cultural environment in which they serve to do their work most effectively.

Throughout Dr. Herzfeld's tenure as ARPA Director and, in fact, throughout the life of the program, ARPA-supported research relating to foreign cultural and social factors encountered no "Camelot"-type political embarrassments. Increasing difficulties in supporting university researchers arose, however, with growing disenchantment with the Vietnam war. Ultimately these difficulties, combined with constant problems in explaining the program to Congress and Vietnam budget pressures (behavioral science university "forward funding" was drastically cut in FY 1968, along with similar cuts in the materials program) simply wore down enthusiasm for the effort. As will be noted, the program was reorganized under Dr. Rechtin to eliminate research on foreign cultures and research with direct foreign policy implications. While it lasted, this controversial part of the behavioral sciences program appeared to be sincerely motivated and the research performed seems to have been accepted as of reasonable quality (whereas the quality of behavioral research under AGILE was subject to considerable attack). In the end, foreign-oriented behavioral research fell victim to a negative environment for which ARPA held little responsibility but could not overcome.

HERZFELD'S DEPARTURE

Herzfeld left ARPA in March of 1967. He had served as ARPA Director for less than two years, but was a powerful influence on the Agency from the date of his appointment to the DEFENDER staff in late 1961. Like his predecessors, Herzfeld had planned to leave the Agency well in advance, but unlike Ruina or Sproull he left in an atmosphere of some discord and with no obvious successor. Throughout most of a stormy 1967, ARPA was to be headed by an Acting Director, Dr. Peter Franken, whose appointment apparently was seen as temporary almost from the beginning.

Two of the elements of conflict leading up to the Herzfeld departure can be readily discerned from the preceding pages. First, growing criticism of ARPA from within the DOD, as well as from Congress, made Herzfeld's image of the ARPA role increasingly difficult to sustain, particularly the image of ARPA as a vigorously independent Agency which could challenge or confront the Services on issues of national importance. Second, it is evident that Foster and Herzfeld did not stand in complete agreement on ARPA's role, its programs or the problems facing the Agency, and personality conflicts between these two strong-willed individuals clearly existed. As noted in previous sections, close relations between the DDR&E and the ARPA Director were instrumental to the development of the influential role gained by the Agency in the early 1960's. These relations no longer existed.

Beyond the above, and apparently an important reason contributing to Herzfeld's departure, was growing interest in DDR&E in transferring the DEFENDER program (which still accounted for close to half the ARPA budget) to the Army. Given the thin line between DEFENDER and the advanced BMD research underway in the Army and perceived weaknesses in the Army program, Foster increasingly leaned toward shifting the effort. This move would have also served to eliminate a source of conflict with which the DDR&E was frequently faced, as the gadfly role played by ARPA in DEFENDER naturally resulted in sometimes abrasive relationships with the Army. With the Army also irritable over AGILE's Southeast Asia activities, efforts to reduce tensions clearly appeared in order at the DDR&E level. To Herzfeld, however, loss of DEFENDER threatened the viability of the entire ARPA program, both because of the size of the effort and because it accounted for a large portion of the Agency's notable successes and its claims to involvement in "Presidential issues." Beyond this, Herzfeld disagreed with the substance of the proposal, telling Foster as he had told Rabinowitz that transfer "would cut off your leverage on the Services," i.e., would result in declining OSD-level control over the Army's ballistic missile defense efforts, as well as over Air Force strategic missile programs to which DEFENDER had contributed through penetration aids and related research.[77] Herzfeld strongly opposed transfer and said that "the arguments went on for a year before I left." [78] While a final decision had not been reached before his departure, heavy shadows lay over DEFENDER as Herzfeld prepared to leave.*

* In late 1966, some $15 million in DEFENDER's penetration aids program was terminated, with the DDR&E deciding to rely on the Air Force ABRES program for continuing research. This was taken as a sign of the increasing vulnerability of the ARPA effort.

Symptomatic of ARPA-DDR&E relations just prior to Herzfeld's departure were a series of "Memoranda of Understanding," prepared in late 1966. Covering the several major program areas in ARPA, each memoranda reviewed the ARPA effort in that program vis-a-vis work performed in the Services and reached agreement on the scope and direction of current and planned ARPA programs. These agreements were "negotiated" between the responsible ARPA program directors and the DDR&E staff members involved in the technological areas concerned, then signed by the ARPA Director and the Deputy DDR&E responsible for that area (in Materials Sciences, for example, the agreement was signed by the Deputy DDR&E, Research and Technology). Herzfeld defended these agreements on the ground that there had been "no ARPA/ODDR&E relationship," good or bad, for some time prior to Foster's arrival. Given the lack of interaction, the Deputy DDR&E's were not using ARPA's talents and results sufficiently, which was bad for them.[79] By the same token, ARPA was ignorant of DDR&E problems and hence the ARPA program was not as responsive as it could have been to ODDR&E. Thus Herzfeld says he saw the agreements as meaning of acquainting the DDR&E Deputies with the details of the ARPA program.

Nevertheless the agreements implicitly reflected a distinct reduction in ARPA's status. Whereas it had previously been a tradition that the DDR&E controlled ARPA through the DDR&E's personal relationship with the ARPA Director, and not through subordinate staff members (Sproull and Ruina were both insistent on this relationship), ARPA now sought the written agreement of DDR&E Deputies for each major program. It appeared as if ARPA felt it needed "protection" from ODDR&E criticism and hoped to overcome it by formal written agreement. The memoranda subsequently came to be known informally within ARPA as "the Treaties," and indeed they closely resembled treaties in form and substance, with ARPA being the weaker signatory.* They were to be cited by Herzfeld's successors as dramatic evidence of the low state to which ARPA-DDR&E relationships had fallen as ARPA approached the end of its first decade. By the time Herzfeld left, the ARPA budget was being reviewed, line item by line item, in the DDR&E's staff meetings for the first time in the

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* An example of the "Materials Treaty" wording:[80]

> We have agreed that the IDL Program should be more oriented to DOD problems. We have further agreed that the manner in which we approach the universities to secure this needed balance of orientation is subject to further discussion between us. However, we have set an initial goal of 50% as the ratio between problems directly related to DOD needs and those with a more tenuous connection. We both recognize that the re-orientation must be evolutionary.

Agency's history. When Rechtin arrived as Director after the seven month Franken interlude, he found Foster trying to control the ARPA program by deferring as much as 90 per cent of its budget and personally interviewing and approving recruits for the ARPA staff.[81]

Herzfeld was exceedingly proud of ARPA and its accomplishments and he viewed the Agency as an essential component of the Office of the Secretary of Defense. He believed it should be used to take on "Presidential issues" on the Secretary's behalf and he clearly felt that: (a) such issues existed and (b) were urgently in need of attention by a non-Service agency. He interpreted attacks on ARPA programs as attacks on the Agency itself and its OSD role. This has been a normal reaction by ARPA staff throughout ARPA's history, but was bound to occur in 1967 when the Services again were hostile, the Secretary and Deputy Secretary found ARPA an irritation, and the DDR&E was making it clear that he felt it probably was time to transfer out DEFENDER, VELA and the Materials Sciences work -- the stalwarts of the ARPA program for a decade -- and to transform AGILE into a quick-fix program responding to the needs of U. S. forces in Vietnam (which is some ways reinforced Service aggravation with ARPA). Ironically, Foster may have been more "pro-ARPA" in an institutional sense than either York or Brown, but he had come to believe that ARPA's survival depended on a programmatic house cleaning and a decided reorientation in purpose and outlook. Herzfeld disagreed and refused to budge. In some sense, then, one can argue that by insisting on his views he and the Agency became a sort of threat to the DDR&E -- an independent director with a quasi-independent agency and a $250 million plus budget as a base, making it clear that he was not prepared to react positively to new signals from the top. On the other hand, the DDR&E's increasingly obvious superior status position and determination to reshape ARPA, persuaded Herzfeld to leave. ARPA very nearly collapsed in the six months after his departure and some would argue that its subsequent "revival" took place at the price of sacrificing much that had been considered the heart and soul of the Agency in years past. Others will claim that it was a remarkable survival performance in the face of tremendous odds. Whatever the correct interpretation, Herzfeld's tenure marked the dividing line between old and new.

CHAPTER VII: FOOTNOTES

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5. According to Herzfeld. Discussion with Dr. C. M. Herzfeld, May 7, 1975.

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11. Ibid.

12. House Subcommittee on Appropriations, DOD Appropriations for 1968, Hearings, 90th Cong., 1st Sess., Part 5, April 3, 1967.

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14. Discussion with Dr. C. M. Herzfeld, July 2, 1975.

15. Discussion with Dr. C. M. Herzfeld, September 17, 1975.

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22. Dr. C. M. Herzfeld, "The Threat of Bigness to Science," Nation, May 20, 1961, 435.

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36. Discussion with Dr. S. Rabinowitz, May 21, 1975.

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40. Unattributed study interview.

41. Discussion with Dr. R. L. Sproull, May 29, 1975.

42. Discussions with Dr. S. J. Lukasik, May 28-29, 1975, and Dr. C. F. Romney, February 10, 1975.

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55. Discussion with Dr. C. M. Herzfeld, July 2, 1975.

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60. ARPA, Annual Report: FY 1966, op. cit., 33.

61. Memorandum for Dr. C. M. Herzfeld from Dr. R. Thomson, "IDL Review," August 1, 1966.

62. Ibid., derived from Figure 1, attached.

63. Herbert H. Test, "The Materials Research Centers," Industrial Research, April 1966, 42.

64. Memorandum for Dr. C. M. Herzfeld from Dr. R. Thomson, op. cit., 9.

65. As cited in Memorandum for Dr. Herzfeld from R. Thomson, "Materials Strategy," August 16, 1966.

66. Memorandum for Dr. MacArthur from R. Thomson, "R&D Analysis," April 12, 1967.

67. "Report on ARPA Coupling Program in Materials," (undated ARPA evaluation for internal purposes, conducted in 1967).

68. Ibid., 29.

69. Discussion with Dr. R. L. Sproull, May 29, 1975.

70. ARPA, Annual Report: 1966, op. cit., 29.

71. Discussion with Drs. Destouzos and Corbato, March 19, 1975 (MIT/Project MAC).

72. Discussion with Dr. J. C. R. Licklider, April 15, 1974.

73. Discussion with Dr. M. Minsky, March 21, 1975.

74. University of Illinois, Proposal for Experimentation in Parallel Computation, October 7, 1965.

75. Office of Assistant Secretary of Defense, Public Affairs, "News Release: ARPA Authorizes Development of Advanced Computer," February 10, 1967.

76. Senate Foreign Relations Committee, Hearings, 90th Cong., 2nd Sess., May 9, 1968, 10.

77. Discussion with Dr. C. M. Herzfeld, May 7, 1975.

78. Discussion with Dr. C. M. Herzfeld, September 17, 1975.

79. Ibid.

80. Memorandum for the Director of Defense Research and Engineering from D. M. MacArthur (Deputy Director, Research and Technology, ODDR&E) and C. M. Herzfeld, "Memorandum of Agreement on ARPA's Materials Sciences Program," September 29, 1966.

81. Discussions with Dr. E. Rechtin, July 7, 1975, and Dr. S. J. Lukasik, May 28-29, 1975.

Chapter VIII

WEATHERING THE STORM

THE RECHTIN PERIOD: 1967-1970

The Setting - 1967

1967 was the only year in ARPA's history other than 1959 in which the Agency had more than two Directors, that is, more than one replacing the other in a normal transition.* There were similar twin crises both years: (1) an inability to tap outside leadership talent, and (2) an upheaval in basic program assignments. It took about six months for Foster to settle on Rechtin, thus leaving ARPA in an exceedingly vulnerable position with an Acting Director and an Acting Deputy Director. At the program assignment level, the crisis was occasioned largely by shifting policy in ballistic missile defense, which led to roughly concurrent decisions: (1) to deploy the Sentinel ABM system, and (2) to transfer the advanced ABM research capability represented by DEFENDER to the Army. In addition the Vietnam War was generating such tremendous demands for resources that all programs were vulnerable to raiding for resources or even closure.

The ABM Deployment Decision. The decision to deploy an ABM system was the pivotal factor in ARPA's world in 1967. It was disclosed in late 1966 that the Soviet Union was deploying an ABM System (called GALOSH) around Moscow. Although publicly released intelligence information indicated that GALOSH was as vulnerable to decoys and/or multiple warheads as the already rejected U. S. NIKE-ZEUS system, the Soviet act of deployment raised the spector of an "ABM gap." President Johnson evidently feared that the Republicans would use this against him in the 1968 campaign, much as Kennedy had exploited the "missile gap" theme in 1960. In the 1967 State of the Union message, therefore, the President hedged his position by deferring a decision on deployment of NIKE-X while requesting "standby funds" for future production of it. Congress responded by appropriating $291 million for construction and $421 million for more research. The situation remained in flux as Secretary McNamara testified against NIKE-X deployment and General Earl Wheeler, Chairman of the JCS, came out strongly in favor of deployment.

* In 1959, Roy Johnson was replaced by Critchfield, who immediately withdrew his name in a spate of controversy; an Acting Director served briefly, followed by appointment of General Betts. In 1967, Herzfeld was followed by an Acting Director for six months, who was in turn replaced by Dr. Rechtin.

The "straw that broke the camel's back" of resistance to deployment was the first Chinese hydrogen bomb explosion in June 1967. This event added considerable strength to the pro-deployment forces, who would now argue the value of a "thin" ABM system to protect against a presumed unsophisticated Chinese threat into the 1980's. This argument was made, depending on the spokesman, either as a substitute for the Soviet threat or as an addition to it, and as either a foreover "thin" system or as a system that could be upgraded in the future. Johnson finally made the decision to deploy. McNamara reluctantly announced it on September 18th describing it as a development justified only on "marginal" grounds.[1] McNamara, at odds with the Administration on Vietnam and other matters in addition to ABM policy, resigned in March 1968.

The Vietnam War. By 1967 the Vietnam conflict had become an enormous political liability. No end was in sight. The impact of the war was amply illustrated by the President's budget message: $12.3 billion in supplemental FY 1967 funds for Vietnam alone, $21.9 billion for Vietnam in FY 1968, and a total FY 1968 DOD appropriation of $72.3 billion (compared to $49.6 billion in FY 1965). American troops in Vietnam increased to 485,000 during the year, plus another 83,000 in Thailand. There were five short-lived truces in 1967, none leading to negotiations or a significant cease fire. The North Vietnamese and Viet Cong remained relatively strong. At the same time, the election of President Thieu in September appeared to stabilize the South Vietnamese government. Thus the stage was set for seven and a half years of protracted conflict, ultimately ending in the 1975 collapse of the Thieu regime and the victory of Communist forces.

In the United States the Vietnam conflict continued to have a corrosive effect. Demonstrations and protests were held throughout the country, peaking with the march on the Pentagon in October. Senators Fulbright and Mansfield stepped up their criticism of Administration policy. Congress adopted a weak declaration on Vietnam policy, voicing support for American troops but urging stronger efforts for peace. Charges were made that the war was having a strong retarding effect on progress in social and civil rights programs. Martin Luther King suggested a merger of the peace and civil rights movements. President Johnson's popularity continued to decline and an embarrassing showing in the spring 1968 New Hampshire primary finally precipitated his decision not to run for a second full term.

Other Events. Other national security events and issues in 1967 included continuing conflict over the F-111, defeat of McNamara's request for a fleet of fast deployment logistics ships, concern over possible Soviet development of a fractional orbital bombardment system (FOBS), severe Congressional criticism of M-16 rifle malfunctioning, and unsuccessful efforts at draft reform. University-government relations, already at a low level, were damaged further by revelations of secret CIA funding of campus groups, notably the National Student Association. Aside from Vietnam developments, major international events included the decisive victory of the Israelis in the short June war and conclusion of the outer space and nuclear non-proliferation treaties. Congressional restrictions on foreign aid and on arms sales were additional issues during the year.

ARPA was directly affected by many of these external events. ABM policy developments threatened the viability of its largest program, Vietnam budget pressures restricted new initiatives in advanced technologies and raised questions of "relevance" about existing work, and relations with the scientific community, especially the universities, deteriorated markedly.

The DDR&E's Perspective

By mid-1966, ARPA was in immense trouble. As noted previously, McNamara and Vance were thinking of abolishing the Agency and Foster continued to feel outnumbered by its critics. In Foster's view, the only way to head off abolition was to make significant and obvious changes. Among the most vexing of the criticisms, discussed earlier: alleged toleration of an "academic" atmosphere, undue pretensions to independence in both Agency operation and espousal of defense policy positions, management deficiencies, a propensity for conflict with the Army in the context of missile defense and Southeast Asia, and apparent continuation of projects for their own sake. If anything, these disturbing issues intensified after Dr. Herzfeld left.

Foster commenced to make major changes that seemed to rip ARPA apart, though he claimed to be a strong supporter of the ARPA concept. Indeed Foster certainly uses far stronger language than York or Brown in defense of having an ARPA. Unlike his two predecessors, he did not believe that there was a shortage of exciting new technological opportunities to work on. Thus it was necessary to:[2]

> [G]o get some zealots and give them a charter.... It takes very special people to think up and conduct these programs. They must be permitted to do it in their way and you must give them a chance.

He admired ARPA's "can do" attitude -- "ARPA is a contracting group that gets it done"[3] -- but he never seemed to sense or resolve the potential contradiction between a "quick-reaction" agency and doing "advanced research," which often is a long term proposition. We noted in Chapter VI that Sproull, in trying to talk himself out of the conceptual dilemma posed by the presence of AGILE in ARPA's program structure, tried to have it both ways, in theory, by claiming that ARPA could do both -- move quickly as things come up and take a more long-range scientific point of view. Foster, as will be discussed below, was to emphasize the quick reaction side of the coin. He believed that an ARPA was needed to devise and run "aggressive, accelerated, ambitious programs."[4] All Foster says that he wanted to do was "to go back to ARPA's fundamentals, to the things that are unique to it."[5] In discussing the qualities of this "uniqueness" Foster often uses the word zealot, i.e., ARPA exists to provide a special home for or access to the gifted:[6]

> There are a whole lot of important things that need to be done. Normally you cannot get the zealot you need to do them, or get his superior to do such things. That is why ARPA exists.

Indeed he viewed ARPA as the only place in DOD where a DDR&E could put such people, unhampered by layers of bureaucracy, and encourage them.

There could hardly be a more expansive vision of ARPA. Unfortunately it was not perceived to be associated with Foster by those in ARPA in 1967-68. In fact the reverse seemed the case as criticisms and apparent snap judgments like the DEFENDER transfer decision were issued from ODDR&E. As Foster searched for important things for ARPA to work on, internally the staff saw only pressures for eliminating Agency projects and programs.

Part of this communications problem undoubtedly was conditioned by the filter of the omnipresent Vietnam conflict. There were both positive and negative effects, but with the net effect certainly in the latter direction. In terms of budgets, the Vietnam drain was a major inhibition on new ARPA initiatives, while at the same time ARPA was a convenient source of funds to be tapped for quick-fix Vietnam projects and hence a valuable resource for the DDR&E. Yet even as ARPA would be used for Vietnam projects the expenditure of funds through ARPA engendered bitterness in the Services, whose own programs were tightly constrained. Some ARPA staff left the Agency out of resentment at Vietnam-justifiable raids on their programs and/or unhappiness with U. S. policy in Vietnam. They and others felt that ARPA's advanced research mission was being reduced to a sham. Many in and outside of DOD began to regard ARPA, derisively, as "Johnny's hobby shop." For them, the ZAP channel mentality came to symbolize ARPA's low point as an institution. Questioned about this, Lukasik summed up the situation as follows: "It's totally true. That was ARPA's low point. They were right. I was there. It had no regard for the science, for good research, for universities, for quality...."[7]

The psychological effects of Vietnam were probably much more important than budgetary issues per se. ARPA's Vietnam-related work was often seen as "second-guessing" the Services and its hardware development projects either as implicit condemnations of existing military capabilities or as wasteful, irrelevant gadgets. ARPA's non-Vietnam work, particularly that based in the academic community, could be seen as non-responsive to urgent Vietnam needs; or even as almost "giving aid and comfort to the enemy." The frustrations and harsh feelings of this era are difficult to exaggerate.

In the center of this storm, Dr. Foster felt very strongly that R&D had an important role to play in the Vietnam conflict. Foster's view of the value of ARPA was therefore highly influenced by his perception of its utility in Vietnam-related R&D. It is perhaps ARPA's perceived usefulness in this context, as much or more than any other factor, that impelled Foster to continue to support the Agency despite the problems and reservations described above.

The DDR&E's emphasis on ARPA's role in Vietnam matters is most clearly illustrated in the FY 1969 ARPA testimony before the House Appropriations Committee, which Foster personally presented. The Vietnam emphasis is highlighted in his lead statement:[8]

> I have already mentioned various research and exploratory development results in which ARPA has played a major role, particularly ballistic missile defense and penetration aids, nuclear test detection, and R&D for Vietnam. (Underline added.)

This is even further reinforced by his description of ARPA's major missions:

> (1) multiservice in nature or at interservice boundaries, such as counterinsurgency, information processing techniques, and advanced sensor concepts;
> (2) clearly important to the DOD but in areas where service missions are not yet clear, such as the initial work in advanced ballistic missile defense concepts and nuclear test detection and countermeasures; and
> (3) especially quick-reaction R&D needs, such as for Vietnam. (Underlines added.)

Thus, of the three missions presented, counterinsurgency research is the first example given for one and Vietnam R&D the only example for another. Another large program effort noted above, advanced sensors, was also largely redirected to Vietnam applications. Running through Foster's statements covering the various ARPA program offices, the following extracts are illustrative of the dominant concern with Vietnam:[9]

(1) Information Processing - "ARPA recently helped General Westmoreland with an analysis of the overall data processing requirements of his command....";

(2) Behavioral Sciences - "Studies of communication among insurgents in various circumstances and cultures revealed common features, which should help future counterinsurgency planning";

(3) Overseas Defense Research [AGILE] and Advanced Sensors - "contributed quick response R&D for Vietnam.... [elaboration follows]";

(4) Materials Sciences - budgetary cuts described as "necessary a result of the need for moneys for Southeast Asia ... [the IDL's] are not as high priority as the fulfillment of urgent needs for Southeast Asia" and;

(5) DEFENDER - "A program in the development of an airborne phased-array radar for application to tactical problems in Vietnam will be turned over to the Air Force in fiscal year 1969...."

Foster both justified budgetary cuts in non-Vietnam related offices (e.g., Materials) in terms of the priority of Vietnam requirements and found Vietnam applications in some of the most unlikely places (e.g., Information Processing, DEFENDER).*

In sum, ARPA staff did not sense a vision of a strong and expansive ARPA emanating from ODDR&E. Instead they were aware mostly of criticism of old programs and tremendous pressures to build a better mousetrap, preferably as soon as possible, for use in Vietnam in an immediate tactical setting. The net effect was a feeling that ARPA was being permanently downgraded. It rivalled and perhaps exceeded the depression that followed loss of all the space assignments in 1959. One thing was clear: perturbed by what he perceived as a badly faltering agency subject to the imminent threat of institutional termination, the DDR&E had, for the first time in the Agency's lifetime, essentially "taken over" ARPA. Perhaps it is well that he did because, according to Rechtin, "It [ARPA] lived because Foster defended it."[10]

* And a long line of unlikely ARPA-supported groups and contractors were turned toward Vietnam projects -- e.g., Jason's high-powered physicists and Lincoln Laboratory's radar experts were both involved in major Vietnam projects.

The Franken Interlude

When Herzfeld left ARPA in the spring of 1967 his deputy, Dr. Peter Franken, became Acting Director. Like so many senior ARPA personnel, Franken was a physicist. He had been involved in early laser studies and made important contributions in the field of spectroscopy. His entire professional background was university-oriented, primarily at Michigan and Stanford. Franken had come to ARPA as a scientist, with no experience in management and without prior involvement or interest in applied military problems. He took over as Acting Director under most inasuspicious circumstances.

As noted above, ARPA was coming under increasing attack, the DDR&E in many respects distrusted the Agency, and it was not clear what could be done about the situation. Franken was quite prepared to assume command as permanent Director, if asked, but it was evident that this was most unlikely. He was in poor health, he was disadvantaged to some extent by his association with Herzfeld and above all he had serious philosophic conflicts and other differences directly with the DDR&E. On the face of it, Franken had to be even more unacceptable to Foster than Herzfeld was because he personified a point of view that the DDR&E rejected out of hand. To cite Franken on ARPA's role:[11]

> It was not ARPA's job to start new things, its job was to serve the scientific community, in the Department of Defense; ... not to lead the way ... [but] to be receptive to unsolicited proposals, ... not to do science ... [but] to make scientists better able to do good science.

Franken's view was similar to Sproull's comment that ARPA could afford to take a longer view with greater "scientific involvement" than the Services, but it also confirmed Foster's worst fears that ARPA was becoming too academic, too unstructured, too close to being the National Science Foundation of the Defense Department. Franken valued ARPA's ability to respond quickly to high quality research ideas. This was in line with Ruina's ranking of quality over relevance, but completely out of tune with Foster's view of the tight relevance criteria which should guide ARPA activities. To top it off, Franken was also basically anti-Vietnam War in orientation, yet that problem of necessity came to dominate the DDR&E's attention.

Given their obvious incompatability, Foster searched energetically throughout the summer of 1967 for a permanent ARPA Director. In particular he sought the advice of former colleagues in the AEC-DOD laboratory system. One of them, Dr. Pickering of the Jet Propulsion Laboratories, recommended Dr. Eberhardt Rechtin, then an assistant Director at JPL for tracking and data acquisition. Rechtin accepted and arrived at ARPA in

November 1967, thus ending what some contemporaries, including Rechtin, have called a "desperate hunt." Rechtin, an electrical engineer with a Ph.D from the California Institute of Technology, had extensive management experience as director of JPL's Deep Space Network for NASA. Though he had had only passing contact with ARPA (in the early space days) and had far more experience with NASA than with the DOD, Rechtin was very strongly oriented toward the role of technology in national security issues. This orientation pleased Foster, who was attempting to reverse what he considered the academic isolation of much of ARPA from urgent Defense problems. In addition, Rechtin shared Foster's conviction that R&D had a major role to play in the Vietnam conflict. Rechtin was "Johnny's man," and ARPA needed one.

The effects of the Herzfeld-Foster disagreements and the ODDR&E's dissatisfaction with ARPA were greatly magnified by the gap in leadership during the Franken period. Foster intensified his personal concern with the details of ARPA budget, program, personnel recruitment, and administration. This was actually encouraged by Dr. Franken, who (perhaps due to his realization that he lacked a mandate from Foster or to a recognition of his lack of management experience) tended to be rather demanding on the DDR&E's time to address issues which normally would have been resolved internally within ARPA. Foster recalls that he even commissioned the OSD Comptroller to do an independent audit of the ARPA program, which he then used as the basis for cutting the ARPA budget by $30 million.[12] One of Rechtin's primary tasks was to restore some balance to the ARPA-DDR&E relationship.

Rechtin's Mandate

Dr. Rechtin is one of ARPA's most controversial directors. He is associated with a period of maximum turmoil, which was unavoidable if he was to carry out radical surgery on Foster's behalf. He was a complete disciple of the doctrine of program transfer. It should be understood, however, that he was also a strong advocate of the accomplishments of programs like DEFENDER and VELA:[13]

> DEFENDER was very good and it had a counterpart in VELA which I thought was very good. And until you get down to where you know all the answers, it was appropriate for ARPA to continue.

His point was that they had succeeded and hence should be passed on. Above all, as numerous examples below indicate, he was a keen supporter of the ARPA idea. Thus the appointed change agent started from a position of basic attraction to ARPA, not hostility, although many at the time were not so sure. From the new Director's perspective, however, drastic measures were mandatory because nothing less than survival was at stake:[14]

> The problem I was confronted with, the first and most immediate problem, was that ARPA was in very considerable danger of being terminated. I didn't know that when I took the job on. I found it out almost in the first week. And about a year or so ahead of that there had been discussions all the way up to the Deputy Secretary level of killing ARPA altogether.

Assessing this threat, Rechtin devised a number of principles which he adhered to rather rigorously. The first, and perhaps in the long-run the most important in terms of its long-term impact, was assuming a "low profile:"[15]

> What I tried to do was to get ARPA established as a well-recognized entity, well-run, doing the job it was assigned to do, and keeping a relatively low profile. That, I think, kept ARPA intact.

Second, "damn fool" projects were to be eliminated. Referring to AGILE's "mechanical horse" project as an example, Rechtin said:[16]

> I killed off what I called 'damn fool' projects, because I could see that the Congress would use those to destroy the credibility of ARPA. [Foster] wanted someone [as Director] who knew enough technically at least not to get flim-flammed by all the kinds of characters that, as you know, show up and talk to ARPA and want to do all kinds of damned fool things.*

Third, Rechtin insisted that ARPA cease being the NSF of the Defense Department, and that meant sharply reducing ARPA basic research support at universities. In part this represented a position that, philosophically, DOD should not take on responsibility for sustaining university research. In part it reflected considerable pique at university criticism of Vietnam policy. Rechtin felt that APRA, already on shaky pins, was multiplying its vulnerability under these conditions by being a champion of university support. Sometimes this issue was discussed under the heading of "relevance" to military needs; however, Rechtin and Foster tended

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* The AGILE Chief Scientist who approved the ARPA Order on this project likened it to "sending a million dollars to chase dimes around a rice paddy." Using it to illustrate the flavor of the time, he added: "We knew it, but we did it.... ARPA just behaved like the nation did [on Vietnam] and was as effective as what the nation did." (Discussion with Dr. H. Hall, July 7, 1975.)

to be ambivalent about what was or was not relevant. The Mansfield Amendment later transformed relevance into a politically significant issue and university recipients (and their sponsors) were caught in the middle:[17]

> [T]hey didn't dare stand up and say what they were working on was for purposes of defense [because of student and faculty opposition]. But suppose they made the other mistake of saying: 'Sure we're getting money from Defense, but we're not really doing anything related to defense.' Whish. You get shot through the other temple. The Congress says 'What the hell is Defense putting that money up for? The professor himself doesn't know that it's any good for anything. He says it's not good for Defense anyway.'

There w s another aspect to the anti-university policy. The Services were successfully attacking ARPA in the Secretary's office and some believed that ARPA's identification with the universities was an important reason for their opposition: "ARPA had become too academic for military tastes ... the military couldn't understand the kind of people who were running ARPA at the time."[18]

Fourth, Rechtin had a charter to transfer programs:[19]

> I felt strongly about ... getting things moved out, getting it to where the Services as customers would want to have the ARPA things, were glad to have us around. And I hoped the Services would then give their support to ARPA in the councils where the Services were, which is up in the Secretary's office, where we didn't get very often, and in the Congress.

More than anything else he sought to institutionalize the principle of program turnover in ARPA. There were three main reasons: (1) to insure that ARPA was always responsive to the DDR&E's requirements, (2) to maximize the likelihood that DOD-relevant work would be undertaken, and (3) to reestablish favorable ARPA relations with the Services, who were so prominent in criticizing the Agency. Note that this "requirement" was self-generated; it was not inflicted on the Agency by the Congress. In fact it is not entirely clear that the transfer doctrine helped on the Hill.* Nevertheless, under Rechtin rapid transfer of projects out

* To boast, as Rechtin subsequently did, that it was hard to tell whether a particular project was a Service project or an ARPA project because ARPA and the Services were so closely coupled, is a two-edged sword raising 'why ARPA?' questions. Lukasik later toned down this point.

of the Agency and into the Services became a watchword:[20]

> What Rechtin brought into the Agency was emphasis on the timely transfer of new projects and ideas into and out of ARPA. This had always been part of ARPA's operating concept, but for many years the agency had been preoccupied with a handful of large and very demanding efforts such as DEFENDER, the ABM technology program, and VELA, the space-, ground- and underwater-based system for nuclear test detection....
>
> 'One of the problems of any organization such as ARPA,' Rechtin said, 'is to keep it from silting up, from continuing to do projects which it has been doing and never wants to let go, from getting a vested interest in a particular project of technology. It is a very natural thing for the people who are doing it to want to keep on doing it, to make it better, to make a lifelong thing out of it. But not in ARPA. It should be transferred someplace else where the next driving force is to use it operationally.'

Rechtin amplified this basic point in discussion:[21]

> I felt that it was absolutely essential to work out a transfer mechanism to where ARPA projects transferred to the Services, and where it was ARPA's responsibility to make sure that happened. That it was not the Services' responsibility to recognize ARPA's brilliant ideas.... It was ARPA's job not only to do things professionally, but to get them transferred successfully. I made it very obvious to everybody in ARPA that success had to have both elements: professional work, which I said was easier to have, and successful transfer.
>
> That did a lot of things for us. Most important of which, it made the Services feel they had a handle on ARPA, because they felt 'OK, if it isn't any good, we don't have to accept it....' Well, since it was quite good and we worked hard about letting people know about it, we got better and better at it. It also meant that the ARPA guys couldn't just walk around as though they were independent of everybody and 'Who the hell cared?' Instead, they had to sit down and work with the Services and convince them that what was going

> on was better than what they had at the time. Because the Services' problem was that anytime they accepted something from ARPA, they had to kill something else. Therefore you had to be better than something else in the Service. That's uphill for them. We felt that in a roughly $200 to $250 million a year budget, if you're going to roughly turn that over every four years in budgets, that you had to be transferring $50-$60 million of stuff a year into the Services. And if you weren't you weren't doing the job.

There is no doubt that ARPA had neglected "transfer" issues. More often than not it was "growing technologies" anyway and assumed that "somebody else" would pick them up and develop the ideas through to something operational. Many such hand-offs may have been poorly executed or missed altogether. But Rechtin's belief in a 25 per cent transfer of projects annually was strong medicine. It implied a very high success average and a continuing string of replacement projects and funds.

It is unfair to cast Rechtin's mandate entirely in negative terms. There was a more positive aspect to his mission and he was genuinely dedicated to it. As noted, Foster wanted to go back to "ARPA's fundamentals," to restore its past glories. Rechtin recalls receiving that instruction and acting upon it: "So I went back to the foundations of ARPA, ... back to the original ARPA."[22] Rechtin believed that ARPA's "original" role had been lost sometime in the mid-1960's. As he put it:[23]

> When I was asked to be the head of ARPA, I was honored ... because I respected what ARPA was trying to do ... particularly in the early 1960's when the ideas of ARPA were those I tried to get back to when I was the Director. The idea that you ought to be out ahead, that you ought to be setting up so that we didn't get surprised technologically by the Russians....
>
> This is <u>the</u> definition of ARPA.... You have to have some idea of what the military problem is. Then you start asking yourself 'If I'm sitting here, what could the other guy do that would hurt me the most. What would <u>really</u> undercut us?'....

Or as Rechtin stated even more strongly in his FY 1971 testimony before the House Appropriations Committee:

> In precluding sputniklike surprises, ARPA's role is to conduct high-risk R&D of a revolutionary nature in areas where defense technology in the United States appears to be falling behind or in areas when we cannot afford the risk of falling behind. (Underline added.)

Echoing Foster's view of ARPA as the institutional focus for zealots capable of cashing in on technological opportunities, Rechtin position, as summarized by Space-Aeronautics was as follows:[25]

> ARPA was to fill the obvious gaps that lay between the military service R&D efforts. It was to seek out deliberately the type of technology that could dramatically upset the strategic balance of power on either side. The services would handle evolutionary R&D on existing systems. ARPA would seek revolutionary avenues for Defense.

Foster also described ARPA's role in terms of trying to "find a revolutionary thing that made a difference,"[26] so he and his chosen ARPA Director were of one mind.

To illustrate what Dr. Rechtin may have had in mind as the "revolutionary" accomplishments of the early ARPA, a partial listing cited in his FY 1971 testimony is illustrative. The list included:[27]

> (1) "initiation and management" of Explorer and Mercury, and of navigation, communications, weather and surveillance satellites;
> (2) "developed" Centaur;
> (3) "developed" the clustered SATURN booster;
> (4) "conducted the R&D" on the 1.5 million pound thrust booster later used for Apollo;
> (5) propellant research "leading to the present family of propellants" in Polaris, Poseidon and Minuteman;
> (6) ESAR - "major spinoffs including all subsequent phased-array radar developments"; and
> (7) interceptor technology "now incorporated in Sprint."

This perspective on the early ARPA role is clearly a maximist view. As discussed in various places in this report, both the "revolutionary" quality of some of these items and the role that ARPA played in their emergence are matters of debate. But even deciding the debate in ARPA's favor, it is evident that Rechtin believed much of the program he was inheriting had little revolutionary potential. It also placed a premium on identifying programs that did.

As a consequence, considerable effort in the Rechtin period was expended on attempting to isolate "new directions," partially through more or less formal staff exercises, partially as part of DDR&E reviews of potential new initiatives, and partially in an <u>ad hoc</u> fashion. As a result of these efforts, several new programs were established. Research on surface effects vehicles, floating platforms and the Arctic environment were initiated as the core of a new Advanced Engineering office, and ARPA gradually insinuated itself into underseas warfare research problems. Research on military geophysics, including earthquake control, was begun in the Nuclear Monitoring Research office. An effort was made to integrate a series of tactical warfare related projects into a program called "Ivory Tree," envisioned as a successor to AGILE. The behavioral sciences program was thoroughly restructured and a number of new projects initiated. There were many other examples. Throughout this process, however, it proved consistently difficult to develop sound, substantial programs that were acceptable to Congress, the Services and OSD, and which also met the criteria of transferability and revolutionary potential.

In assessing the written record and the views of contemporaries about this period, it seems clear that ARPA netted out with somewhat more "transfer out" and "low profile" than it did "revolutionary advance." The good old days were dead. As much as Rechtin aspired to restore them, the prospects were remote:[28]

> We kept ARPA low profile to keep it protected, because there were an awful lot of big guns going off over our heads. Congress versus Defense. And different wings in Defense having different ideas. And the Vietnam war ... and I wanted to make sure that ARPA, which really wasn't an outfit with all that much clout, didn't get clonked in the process. I used to use the Russian proverb 'If you're a clay pot, don't get caught on the stove with iron kettles....' This was sure different from the early ARPA which was very high profile ... reporting in at Presidential levels for all practical purposes. And it was working on Presidentially important things. That was the way it got set up. And Herb York was calling the President's office a fair amount of time.... You're working on ABM, counterinsurgency and all kinds of things which are first order national problems, even somewhat above Defense in a way.... That was the original ARPA. Well, when I was there it sure wasn't.

Not only were there no Presidential issues or PSAC referrals to work on (Rechtin presided over transfer of all the old holdovers), the flow of program assignments from the Secretary and the DDR&E dried up:[29]

> In the time I was there, we didn't get any instructions top down that we didn't know of or start ourselves, I don't think. That doesn't say it couldn't have been done. Maybe it was because we were just a little bit ahead of the game and were proposing before the instructions came in. Maybe it was because there weren't things they felt they needed ARPA to do at that particular stage....

Foster has confirmed that he looked to the ARPA Director to recommend program assignments.[30] Most troublesome to Rechtin, there seemed to be few significant ideas to promote. The York-Brown evaluation seemed most accurate: "At the time, frankly, we had more money than ideas. Throughout my total time ... we had more money than ideas, I mean good ideas that were worth funding even in a high risk environment."[31]

Dr. Rechtin was engaged in an extremely complex balancing act, hoping to safeguard ARPA's immediate survival via large-scale transfer of old programs, removal of friction points such as university basic research, and adoption of a low visibility posture in the Department; and simultaneously desiring to establish a revived sense of mission in the Agency similar to its "Golden Era" (but without many of the characteristics of the Agency in that era) while recognizing that there were no more major Presidential, White House, Secretarial, or even DDR&E assignments in the cards and believing that there was a paucity of exciting scientific and technological ideas to work on.

The result, at the level of Agency operations, sometimes was contradiction or paradox. For instance, Rechtin sought very tight control over programs, yet wanted to be revolutionary. As he put it: "Although I'm conservative, I've also probably supported more high risk projects than anybody else."[32] ARPA staff found it very difficult to be conservative and high-risk at the same time. Likewise they often found it difficult to rule out university capabilities while seeking "far out" ideas to support. Again, the new Director saw a contradiction not clearly perceived by the staff:[33]

> I felt that ARPA had to be a driving force in Defense, had to be doing things which were far out, had to be providing technical leadership -- and most certainly wasn't an academic club. So I drove ARPA pretty hard. I felt we needed to be quite conservative in the way we used our funds, that we had to know what we were doing and why we were doing it.

For him, ARPA had lost the capacity (if it had ever had it) to spot revolutionary potential of value to Defense in relatively unstructured basic research areas, and it had clearly lost the mandate (assigned or self-selected) to sponsor exciting science for its own sake, after the fashion of Arecibo. He was definitely right about the latter and could have been correct about the former.

Management of the Agency

It is obvious that given the turmoil in the Rechtin period, management problems would abound. There were, however, a number of constants. The basic administrative machinery continued to function and Rechtin operated much like his predecessors. He felt that the policy of not having ARPA laboratories was correct and believed that ARPA's authorized staffing levels were adequate. Rechtin reported directly to Foster, personally. He had no Chief Scientist, Program Council or advisory committees and he went one-on-one with his office directors, i.e., he retained the concept of relatively independent program heads. Indeed some feel that he was too permissive with these individuals, a few of whom were not well-equipped to operate independently and others who may have taken undue advantage of the opportunity to promote projects of questionable value. Rechtin describes his approach as follows:[34]

> [I] seldom turned down an idea. I would modify some. Even the ones I thought were kind of poor payoff. If the office director would make a strong case, I would go along, sometimes modifying it to say 'well, look, before you go too far, I want some kind of result out of this.... Why don't you put in a few milestones, just so that somebody will know something is happening.'

Basically he feels that he continued the policy of following leads suggested by the program directors.

Rechtin also basked a bit in the glories of an ARPA director's flexibility. He felt that if necessary he could always find $10 million to support a promising new idea, normally by deferring expenditures or by borrowing money from other projects that had encountered unexpected delays in obligating or committing funds. "We used to do a bit of 'riding the tiger;' that is, allowing a program to get going even when there didn't appear to be adequate funds."[35] ARPA program managers were aware of this flexibility and some operated on the theory that if they came in with a good idea money would be found for it some place:[36]

> [T]he whole theory of funding in a sense was to look at the overal ARPA activities and ask what things seemed promising, what looks good. So if you come in with more programs that looked good, then you got more money.

This was a pale reflection of earlier days, but still an advantage over the years to follow.

There were plenty of personnel problems. Considerable turnover occurred, some because of disagreement with the major program transfer decision, some because of unhappiness with Foster's emphasis on making ARPA a Vietnam quick-response agency and/or disillusionment with Vietnam policy in general, and some as a planned part of the transfer actions. The DEFENDER "head graft" indeed depended in important respects on strong people going with the program to Army and many of ARPA's best, including the DEFENDER office director, did so. Rechtin saw himself as a tough manager, willing to make changes when they were needed:[37]

> I'm a hard hitter. I expect things to happen. I don't worry about whether people are happy or not. I think happiness comes out of success.

Most of the turnover, however, seemed related more to disagreement over policy and program decisions. Historically, ARPA had drawn a very high percentage of first quality military officers on assignment. By Rechtin's period, this was no longer the case. ARPA's general nose dive in status and problems with the Services made it somewhat unattractive. Rechtin says that both ARPA and DDR&E had earned a reputation for being bad for careers and his "low profile" policy really did not help this situation. It was a problem passed on to the next Director. Some contemporaries feel that perhaps the most serious difficulty faced by the Agency during this period was an inability to recruit and retain quality personnel, military or civilian, on anything like the scale of previous years.

Given the tremendously increased concern over Defense budgets, the relations of supposedly privileged DOD contractors came under considerable attack, especially the special category of non-profit contractors categorized as Federal Contract Research Centers (FCRC). ARPA was a major and long-stand supporter of three of these institutions -- RAND, IDA and Lincoln Laboratories -- and used many others as well. Accusations were voiced that such organizations were unfair means of avoiding regulations governing competition, served as a subterfuge to avoid civil service hiring, and were a technique for avoiding accountability to Congress. Since ARPA's reliance on FCRC's was particularly strong it took much of the criticism. This issue was complicated by relationship to other matters of dispute, e.g., RAND was involved in the AGILE program and Lincoln obviously was connected with a major university. DOD budget tribulations also triggered closer Congressional and DDR&E attention to fiscal and administrative issues, and ARPA's long-standing problem of unobligated balances and other difficulties associated with contracting through Service agents became specific irritants. ARPA's administrative and fiscal controls were of necessity looser than others, given the absence of an ARPA contracting mechanism, but critics were not in the mood for discourses on comparative public administration.

Rechtin found ARPA's "loose" management structure easy to work with, but potentially worrisome. AGILE's problems drew most of the spotlight, but Rechtin felt that ARPA's accountability on projects in general was one of the most important continuing issues that he had to face throughout his tenure as Director. The problem, as he saw it, often was lack of feed-back. Rechtin is far and away the most lucid of the ARPA Directors in pinpointing this aspect of ARPA's style:[38]

> [W]e had a great way of justifying and spending money [but] we didn't have any way of finding out what happened next.... There was no report-back scheme. The report-back we had was the project guys going out there and knowing what was going on -- and if it wasn't right, to change it. But there was no formal report-back as to what progress had been achieved. What milestones had been met.

At a time when the Agency was under attack from every quarter and susceptible to serious budget cuts, and without the prestige of "Presidential" assignments to justify speedy action, this loose state of affairs was dangerous. Rechtin felt the Agency was especially vulnerable to a standard audit, simply on procedural grounds. He had no reason to suspect abuses, but simply had very little hard information as to how the money actually got spent:[39]

> I felt it was a weakness that we did not have an explicit, obvious report-back system that you could share [with] somebody, that indeed the money was spent for what we said it was.... We did all right because our project leaders were good enough and skilled enough and honest enough that it was a reasonable risk to take that money wasn't being squandered someplace.... But I was nervous and I passed my nervousness on to Steve [Lukasik] as a parting gesture.

It was clear that Rechtin felt he was mostly "going on good faith." His attempts to control this situation were not helped by the constant demands for ARPA to "shell out" on short notice for Vietnam. However worthy the motive, ARPA's servicing of ZAP channel requirements and other Vietnam-related matters for Foster strongly reinforced the image Rechtin was trying to overcome. It made ARPA look "fat," "slack," very loosely-managed, and rather vulnerable.[40]

Rechtin in part may have been feeling the long-term effects of the decision to minimize ARPA management structure, which worked well under "normal" conditions, but placed immense burdens on a Director in the chaotic conditions of 1968-70. The situation was later exacerbated by Rechtin's assumption of the responsibilities of Deputy Director of Defense Research and Engineering in 1970, while retaining his ARPA hat. It is probably no accident that Rechtin's successor was to devote more attention to management issues than any other ARPA Director. The following cameo description is illustrative of Rechtin's concern and Lukasik's inheritance:[41]

> I never felt as Director that I had an easy check that things were going mechanically the way they were originally planned. I'd signed off that something should be done and that it was OK to put money on it, with these people or with these objectives (sometimes they didn't even have those very straight). But there wasn't a corresponding piece of paper that came back (say, once a year) ... saying that.... it met milestones[etc.].

The Mansfield Amendment

A discussion of the environment for ARPA research in the late 1960's would not be complete without mention of the so-called Mansfield Amendment. This amendment, actually introduced by Senator Fulbright* during debate on the 1970 Defense Procurement Authorization Act in August 1969, was intended to restrict the scope of Department of Defense sponsored research to ensure greater relevance of such research to military requirements. Incorporated into the 1970 Act as Section 203 (PL 91-121), the amendment read:[42]

> None of the funds authorized to be appropriated by this Act may be used to carry out any research project or study unless such project or study has a direct and apparent relationship to a specific

* Senator Mansfield had evidently prepared a similar amendment, in the event the Fulbright measure was defeated and was the most vocal defender of the amendment.

military function or operation.

This new, strict criterion of relevancy was almost immediately attacked from a variety of sources, and in considering FY 1971 legislation the House, responding to the criticisms, concluded that a "comparable section should not be included because of the adverse impact of narrow interpretations of relevancy on the conduct of basic research."[43] Consequently the FY 1971 legislation adopted a section (Section 204) with more moderate wording, stating that Defense research should have "a potential relationship to a military function or operation." The 1971 Act (PL 91-441) added (Section 205) that:[44]

> It is the sense of the Congress that:
>
> (1) an increase in Government support of basic scientific research is necessary to preserve and strengthen the sound technological base essential both to protection of the national security and the solution of unmet domestic needs; and
> (2) a larger share of such support should be provided hereafter through the National Science Foundation.

In the following year Mansfield Amendment-type relevance requirements were dropped entirely from legislation, although Congressional insistence on increasing the proportion of non-Defense Federal research support was still forthcoming. Budgetary constraints in fact restricted the scope of DOD-supported research far more than the Amendment, which was applied in its strongest form for only one year, and in a weakened form for only one additional year.

The Mansfield Amendment is, however, generally regarded as having much broader effects on Federal research support than its short legal lifetime would suggest. Some of them were partially reflected in the changing style and character of ARPA's research and development effort. Passage of the amendment symbolized growing Congressional concern that R&D was overly concentrated in Defense agencies, and that a large proportion of Federal research funds might be more appropriately allocated through centralized science agencies, such as the NSF, and through civilian mission-oriented agencies. It reflected, in this regard, a desire to "end the Defense Department's long-standing role as the self-appointed complement to the NSF." Beyond the amendment's intent vis-a-vis Defense sponsored research, it also reflected a Congressional attitude toward research support by mission-oriented agencies in general, i.e., that such research funding should have a "direct and apparent" relationship to specific mission activities. Despite the addition of a section the following year reaffirming Congressional support for basic research and the "technological base," it has been widely argued that the long-term psychological effect of the measure (and the underlying attitude it is presumed to represent) has been to make mission-oriented agency bureaucrats much more conservative in supporting basic and applied research, biasing research support toward shorter-term efforts with obvious concrete applications and away from longer-term, less-constrained and potentially more innovative undertakings. It has also been argued that "Mansfield Amendment psychology" has led to the elaboration of all sorts of artificial relevance justifications, which at a minimum create tremendous administrative waste, contribute to distortion of the true directions of research efforts, and serve as an obstacle to objective research review and evaluation. ARPA, like other agencies both within and outside of DOD, felt compelled to develop entirely new layers of paper relevance justification requirements and has appeared to move toward shorter-term programs with more direct military applications; the Mansfield Amendment undoubtedly contributed to these trends.

Addressing ARPA more specifically, the 1969 Amendment was not particularly directed toward the Agency, although ARPA projects were mentioned as examples of non-relevant research in the debate.* After passage of the Amendment, the Defense Department was allowed to establish its own criteria for "direct and apparent" relevance and submitted its reviews to Congress. While this was a rather painful exercise, and some four per cent of DOD research projects were determined to fail to meet relevance requirements, no ARPA project was among them. Both Dr. Rechtin and his deputy, Dr. Lukasik, insisted then and later that ARPA programs were "incredibly relevant." This is not too surprising given Rechtin's emphasis on military relevance and transfer and the fact that ARPA budgets were increasingly tight. As Lukasik put it: [M]oney was so tight that long before Mansfield came along with that silly amendment, we had been forced to apply strict relevance criteria, because we didn't have enough money to do all the things we though needed doing." Hence the Mansfield Amendment really reinforced existing rends toward more restrictive criteria for ARPA project support. Certainly the Amendment virtually foreclosed any

* As an amusing sidelight, Senator Fulbright cited an ARPA evaluation of the "Gama Goat," an off-the-road military vehicle being tested in Southeast Asia, as a prime example of an irrelevant project. He evidently believed that ARPA was studying a real goat.

possibility of ARPA returning to broad institutional support programs such as the Materials IDL effort.*

The pros and cons of the debate on the Mansfield Amendment's effect on Federal support for science are beyond the scope of this study; however, almost all of the members of the R&D community who discussed this question with us felt that its impact was overwhelmingly negative. General Betts, for example, states:[46]

> ... I think the Mansfield Amendment was a kind of idiocy right from the beginning ... we found [many examples] in basic research that were ultimately applied that simply wouldn't have been recognized as being important if somebody with a military orientation hadn't been aware of them. Even though the work itself was not clearly related to military needs.... It's nice and glib to sit there in Congress and say 'don't you put anything in the research that isn't directly relevant to military needs,' but it's another thing to try and guarantee that there isn't some research out there that would help you with your problems if you only knew about it and were completely up to speed within that field. I think the military has to be coupled with universities and very basic research.

The views of Dr. Rechtin, given his very strong personal orientation to Defense relevance, are especially interesting:[47]

> ... the disaster was what happened at the project level, the authors at the justification level in Defense, and everywhere else. What happened? It made everyone of those guys extremely conservative. They wouldn't put money out to a university for anything, unless it was an obvious need to protect a tank. Now what was happening at that time? The universities didn't dare say that they were working on combat arms. In fact the most tragic part of the Mansfield Amendment was what happened to the professors, not what happened to Defense. Defense got it's work done -- hell, it just simply went some

* Dr. Lukasik, in fact, credits the Mansfield Amendment and the revised wording of the Procurement Act the following year with a significant role in bringing the IDL transfer to NSF to a conclusion because the Congress clearly indicated that the NSF should sponsor IDL-type programs.

place else. But the poor guys who were out in the universities were caught in the middle and cruelly so.... We saw guys who quit their jobs because their kids were threatened....

[The conservative trend is irreversible.] It's now permanent. And all the agencies are now with that. As a consequence, it's very hard to get stuff going at the boundaries, or which are uncertain, or have risk to them. Very hard indeed. It's built in. It was a rachet. It doesn't make any difference that later on the thing was taken out again.... The idea that the departments must work only on what's relevant is now very firmly engrained... by relevance you mean a pretty strong application which any idiot can understand.... Because although it's not a matter of law, it's a logical question for Congress to ask. 'What are you doing that for? It's not a matter of Defense.' So it's a matter of Congressional policy, in effect.... It's racheted and you can't back-rachet it. It's permanent damage.

You can see it in the universities. Look at them. How are they getting their facilities? In the old days it would have been obvious. The Defense Department's paying for it, built the facility, keeping it up as a center of excellence... routine.... Now they're getting their money be going to HEW and trying to convince HEW that they can build integrated circuits for devices for the blind or deaf or something like that. [They] get money for little projects, no money for facilities at all. Defense won't [do it]. You couldn't get Defense to build a facility for somebody today at all.

It also hurt the idea of multiple sources of research funds for the same work. One of the fundamental things that Vannever Bush said way back in the '40's, when they were trying to figure out whether you should have a central science funding foundation or whatever, [was] that you should make sure that there was more than one place where a scientist could go to try to get funds.... If a scientist comes into a government agency, he may meet the wrong man -- who doesn't understand him, or doesn't want to do it, or [doesn't] happen to have the money. That shouldn't stop the researcher from trying someplace else, because research is probably going to be useful for lots of different things.... Medical research -- [now] you have to go to HEW. If you go to Defense, you can probably talk

> about research on grenade wounds in the right knee or something, but you're not going to do very broad work there. It's pretty hard to sponsor, because that's the mission of HEW. Well suppose HEW doesn't happen to think much of that particular thing. You have no audience. Everybody's boxed in.... All kinds of things don't happen, and you can see it by what's happening to the support of research and the way it's being supported.... Where's the underlying research base? It's being rapidly eroded, because you can't figure out how to support it unless you tie it very closely into missions. So the researcher doesn't have any alternative. And if he's in a local environment that doesn't help him get into Defense or whatever, then he has got troubles. The Mansfield Amendment, as I see it, has produced a <u>very</u> bad effect as to how the Government could support research across the country.

The President's Science Adviser, PSAC, Ruina, Sproull, Herzfeld, or Franken probably could not have stated the case any better.

The limited salvation in this instance, in Rechtin's judgment, is ARPA:[48]

> The ARPA guys are imaginative enough that if a guy comes in with a research idea, they can think of something. Because ARPA can think of any mission it wants to. You have trouble with the Service organizations when they are tied to specified missions.... ARPA at least [has] a chance.

During his tenure as ARPA Director, however, Rechtin was perceived to be a believer in the Mansfield Amendment; to have "no use for unfettered 6.1" research; and to have abandoned the "tradition nourished by previous Directors that ARPA would support a good man with interesting ideas." [49] The ambiguity of Rechtin's position on the Mansfield Amendment exemplifies the turmoil and confusion produced by the many conflicting pressures of the late 1960's.

<u>DOD Organizational Change</u>

In addition to the programmatic turmoil described above and increasing Congressional constraints, broad questions of Department of Defense organization contributed to continuing uncertainty concerning the ARPA role throughout Rechtin's tenure and subsequently while these issues are somewhat beyond the scope of this history, they had some impact on ARPA and warrant some discussion.

In January 1969, midway through Dr. Rechtin's period at ARPA, the Nixon Administration assumed office. With this change, the first shift in Presidential political parties since 1961, there naturally were major changes in senicr personnel through government. In the Department of Defense, former Congressman Melvin Laird was appointed as Secretary and industrialist David Packard became the new Deputy Secretary. Although there was some uncertainty vis-a-vis the DDR&E position, Dr. Foster was retained, as was Rechtin.

Despite this continuity in the DDR&E office, however, the Laird-Packard administration instituted some changes that were to affect the role of the DDR&E substantially. A well-publicized view of the new DOD appointees, and one particularly associated with Packard, was that management of the weapons acquisition process had become overly centralized in the OSD heirarchy, of which ODDR&E was a key part. As the separate Services bore the ultimate responsibility for the development and operation of weapons systems, the Laird-Packard position was that the Services should also play the central role in the process of requirements definition, R&D and procurement. It was felt that previous Administrations had tended to respond to admittedly real Service deficiencies by shifting responsibility to OSD offices rather than by rectifying problems in Service management, organization and staff capabilities. Laird and Packard therefore moved toward a "selected" or "defined" decentralization intended to upgrade the substantive authority and responsibilities of the Services considerably, while retaining the ultimate policy determination, review and coordinative powers in OSD that had been enormously strengthened in the post-Eisenhower Democratic Administrations.

The impact of this new philosophy on ODDR&E was substantial. Under McNamara, the DDR&E and his staff had, in fact, assumed a large number of substantive management roles which extended to making highly specific decisions on the details of Service research and development programs. In the area of ballistic missile defense, for example, DDR&E officials like Daniel Fink and Lloyd Wilson had extraordinary influence: "DDR&E was very, very powerful.... Fink and Wilson were as tough as nails and were really managing."[50] They made very detailed decisions on the Army's radars, missiles, etc., and even on basic strategy.

The effect of the Laird-Packard approach was greatly to reduce this kind of ODDR&E direct management and to replace it with a much stronger focus on coordinative functions and broad policymaking and guidance. Indicative of this change was the central role given to the Defense Systems Acquisition Review Council (DSARC), a Service/OSD panel chaired by the DDR&E which was used for analytic and advisory purposes in weapon system development, and a new and elaborate series of "Coordinating

Papers" for which the Services and ODDR&E shared divided responsibilities. The changes thus reemphasized DDR&E's "staff" responsibilities and de-emphasized a number of informal "operating" responsibilities which it had accrued over the years.

The full impact of these changes is difficult (and beyond the scope of this history) to evaluate. Foster, in retrospect, views the changes as enhancing the DDR&E's authority by making him a more effective mechanism through which the Secretary could formally structure the Service programs:[51]

> We changed the DDR&E's function: we got him to consider the structure of programs and to monitor them, instead of getting into the military departments, manipulating programs daily.

On the other hand, the direct power of ODDR&E was much less visible in this coordinating role, and there are many who argue that its net influence has considerably diminished in comparison with the McNamara years and that staff quality declined dramatically along with the curtailment of program management functions.

Whatever the final judgment on the changing DDR&E role, it is clear that in the Rechtin-Lukasik period these changes contributed to some of the uncertainty about ARPA's future. As long as ODDR&E were performing various quasi-"operating" functions it provided a direct customer for much of ARPA's work. During the tremendous debates of the mid-1960's on strategic missile design, ballistic missile defense and penetration aids, for example, the ODDR&E staff was exerting enormous influence on the course of specific Service programs in these fields. To buttress its position, it would in turn call upon ARPA. In the course of hot debates with the Services in which many specific technical questions were "swingers," "ARPA was right in the middle, a high point of being the right arm of DDR&E ... a friend of the court."[52] When the DDR&E role shifted, ARPA lost this point of reference and a vacuum ensued. On the other hand, ODDR&E preoccupation with its own bureaucratic survival may have removed some of the edge that it had enjoyed in its relationships with ARPA. In their new role as Service program coordinators, relatively uninterested in ARPA as a source of leverage against the Services, ODDR&E staff members came to be regarded with some disparagement. To quote one ARPA official:[53]

> [a]bout the most useless outfit the DOD ever had -- the biggest bunch of chowder heads they ever collected ... impotent.

Nor was the shift in DDR&E responsibilities accomplished with great smoothness. While ODDR&E was apparently never in the kind of imminent danger that confronted ARPA in 1967, the first two years of the new Administration were filled with considerable difficulty. Deputy Secretary Packard was quite outspoken on the decentralization issue, and coming from an aerospace background, he was the first Deputy Secretary since Quarles who felt at home in technical subject matter. He was not shy about making RDT&E policy decisions. His presence definitely undercut the authority of the DDR&E and helped to downgrade ODDR&E relative to its previous status. Moreover, in examining organizational alternatives the Secretary established a "Blue Ribbon Panel" which in July 1970 actually recommended the dismemberment of DDR&E among numerous OSD organizational changes. While this recommendation was apparently never seriously considered (it would have required new legislation, which the Administration would have been reluctant to propose before a generally hostile Congress), it reflected considerable disaffection with the existing ODDR&E strucutre. The "Blue Ribbion Panel" also recommended centralizing most Defense "6.1" research in ARPA, which would have required a huge increase in ARPA's staff (at least double) and would have fundamentally changed the character of the organization. This recommendation was immediately dismissed as impractical and undesirable in both OSD and ARPA, largely on the grounds that: (1) the Services needed to fund basic and applied research in order to integrate it with their total R&D programs, and (2) central management would be unworkable in practice. Nevertheless the Blue Ribbon Panel's generally positive assessment of the ARPA mechanism was a welcome change compared to the bitter attacks of 1967-1969.

The wide-ranging DOD organizational debate and the changes that occurred throughout the Rechtin period may have inhibited the Agency's effort to rebuild a stable program. In the end, however, redirection of ODDR&E activities to broad program coordination and guidance coupled with ARPA's new emphasis on rapid transfer, contributed to the trend toward a closer coupling of ARPA and Service projects. ODDR&E, whatever its status under the new DOD regime, had ceased by the end of the Rechtin period to be a primary end customer.

PROGRAMS IN THE RECHTIN PERIOD

The ARPA programs in Dr. Rechtin's period were in a process of constant change and adjustment, reacting to the many pressures on the Agency described earlier. The transfer of DEFENDER was the most far-reaching change in ARPA since the space period. A new office, Strategic Technology, arose in DEFENDER's place. VELA and AGILE were gradually deemphasized and office names were rapidly changed to suggest new research direction and to reduce political vulnerabilities. Another new office, Advanced Engineering, was created. Dr. Rechtin's emphasis on project transfer (in its strongest form, setting the ideal of achieving project turnover every 3-4 years) began to affect many programs. This was a period of a few notable successes (such as the ARPA laser program) and numerous failures and efforts of indeterminant impact. The following pages thus describe an ARPA in ferment. Budget trends were downward, with annual totals inching their way close to the $200 million level (see Figure VIII-1).

DEFENDER

In late 1966 the basic DEFENDER organization inherited from the Sproull period remained in place. There were still, that is, branches for Applied Research, Electromagnetics, Mechanics, Missile Phenomenology, Penetration Aids, and Systems. DEFENDER, however, was on the verge of extensive change impelled by the external events described above, notably the mounting pressure for BMD deployment. By late 1967, with Herzfeld gone and transfer of a major portion of DEFENDER pending, some significant organizational changes had occurred. Applied Research and Missile Phenomenology continued as branches with little change in program content. Penetration Aids, however, was renamed Advanced Penetration Aids and Vulnerability, reflecting both a reduction of effort and a reorientation of ARPA's penetration aids work. The core work in Mechanics had become Missile Technology, describing the HIBEX follow-on work much more succinctly than the previous title. Electromagnetics was divided into two branches: Radar and Optical Technology and Over-the-Horizon Detection Technology. The creation of the second office reflects a considerably increased emphasis on this special form of radar since 1965, though ARPA had done some work in the over-the-horizon (OTH) field as early as 1960. Systems was again renamed, now becoming Systems and Technical Requirements.

In 1967 the function of Project DEFENDER was carefully described overall as: "To provide the science and technology associated with the development of advanced strategic defensive and offensive systems, particularly as related to ballistic missiles."[54] This kind of definition of DEFENDER had been given in earlier years, but in the mid-1967 context it appears to relate to an effort to set DEFENDER in a broader context than the NIKE-X/BMD environment; that is, to give DEFENDER the image of a broad-based advanced strategic technology office. For example, discussions of DEFENDER in 1967 stressed OTH applications in early warning technology, a function which was not an integral part of NIKE-X. There was renewed optimism concerning laser and charged particle beam applications, both far beyond NIKE-X. Broad ARPA support, through the PRESS measurements system, of offensive strategic missile improvements was emphasized, as were general applications of space object identification capabilities.

Figure VIII-1

Program Budget History During the Rechtin Period
(Millions of Dollars)

	FY 1969	FY 1970	FY 1971
Appropriations Requests	245	238	223
Actual Budgets	233(1)	212	209
Commitments to Agents	216(2)	224	215
Requests By Program:			
Strategic Technology/ Defender	103(2)	72	66
Nuclear Monitoring/VELA	40	39	35
Materials	24	17	21
AGILE/ODR	26	30	21
Information Processing	25	26	27(3)
Behavioral Sciences	10	5	6
Advanced Sensors	14	30	23
Advanced Engineering	-	13	17
Technical Studies	8	7	8

1 Excludes DEFENDER funds transferred to Army.

2 Includes approximately $40 million transferred to Army.

3 Includes new "distributed information processing" program element covering exploratory development work of the office.

<u>DEFENDER Transfer</u>. The DEFENDER transfer was initiated by Dr. Foster during the late summer of 1967, a culmination of the DDR&E's consideration of this possibility over many months. The key event apparently was a meeting in Dr. Foster's office, which may have taken place in September. It could not be determined whether the meeting followed or preceded McNamara's public announcement on SENTINEL deployment that month, but in any event it took place in the context of the SENTINEL decision which began to take form after the Chinese hydrogen bomb test in mid-year.

The DEFENDER transfer possibility was unveiled in a rather dramatic fashion, Herzfeld's earlier discussions with Foster on the issue evidently having been rather closely held. The Acting Director (Franken) and Acting Deputy Director (Lukasik) of ARPA were invited to an afternoon meeting in the DDR&E's office on the morning that the meeting was to take place. Army and other DDR&E representatives were present. According to ARPA participants, the head of the DEFENDER program had been asked directly by Foster to brief the DEFENDER program, although Franken and Lukasik did not know that, and at the end of the briefing he was asked to present plans for a transfer. Senior ARPA and Army personnel apparently had little, if any, forewarning of the DDR&E's decision and Foster's direct request of the DEFENDER director may have taken place as late as the morning of the briefing. But whether or not there was some degree of forewarning of a major change in DEFENDER -- direct or indirect -- it is clear that the initiative was taken quite rapidly and was generated by Dr. Foster. There was no significant staff planning in ARPA, the Army or ODDR&E leading up to the decision.

What were Dr. Foster's motivations in desiring to transfer the core of the DEFENDER program to the Army? In the view of a participant generally critical of the transfer, they were "very high level. national in character and legitimate in purpose."[55] First, the Army's advanced ABM research under the NIKE-X program had serious gaps and did not have the reputation for quality enjoyed by the DEFENDER program, particularly the Lincoln Laboratory effort. Second, given the SENTINEL decision, the Army was going to have the responsibility for an operational system; to instill confidence in the Army's ability to perform advanced research related to this system in order to upgrade it at a later date, an infusion of talent into the Army was felt desirable. Third, ARPA had no permanent charter in the BMD field (although the DEFENDER assignment dated back to February 1958). Fourth, it was obvious that ARPA had come to have de facto budget ceilings. Should growth be necessary, a new Army agency -- associated with a newly confirmed mission -- might have a better chance of obtaining funds; in theory, at least, ARPA then could turn its attention and resources to other things. Fifth, there appeared to be an underlying feeling that the friction which had characterized the ARPA-Army BMD interface over the years had simply gone on long enough; that ARPA's gadfly role had served the nation well but -- with deployment coming -- the time had arrived to integrate advanced BMD research into the Army program. Sixth, there was some sentiment that major parts of the DEFENDER program were no longer "advanced," at least not from the perspective of truly "high risk," "revolutionary" undertakings which were central to the Foster/Rechtin view of the ARPA role. The PRESS radars and the measurements program, for example, were recognized to be of high quality and very important, but were now part of the state of the art and were not efforts continued as high risk endeavors to prevent some potential "technological surprise." Finally, the legacy of dissatisfaction with ARPA's management performance, independence and "academic" tendencies undercut its care for retaining the DEFENDER work, particularly with the prospect of a major revitalization of the Army's role in BMD.

As Foster says, however, his basic rationale for the transfer was deficiencies in the Army, not in ARPA: "There was something lacking in the Army program. They lacked the talent and they needed it."[56] He considered ARPA's original DEFENDER role, serving as a qualified neutral judge as one Service tried to defend and the other tried to penetrate, to have been unique: "What was more important? ... [ARPA] made a tremendous contribution. The Secretary of Defense and the nation were extremely well served."[57] The problem was how to upgrade the Army program. Another participant in the transfer process described this rationale as leading to the conclusion that the Army needed a "head graft," that is to acquire more of the quality of BMD talent that had become associated over the years with the ARPA program.[58] This meshes well with Foster's own recollection of the decision, for in discussing the issues, he states: "This [the transfer] was a risky proposition because the graft might be rejected and you would have given away the back-up capability."[59] The September meeting in the DDR&E's office essentially expressed Foster's strong intent that DEFENDER, or major parts thereof, should be transferred to the Army. It was left to Rechtin, appointed Director in November 1967, to carry out the decision. The formal transfer action was codified on paper in March 1968, about five months after Rechtin's arrival.

There was significant resistence to the transfer within ARPA/DEFENDER; there was considerable uncertainty as to <u>what</u> and <u>how much</u> might be transferred; there was debate within DDR&E and the Army as to the form of transfer. Dr. Foster's expression of intent was therefore not a hard final decision, and conceivably could have been reversed if his newly-designated ARPA Director had devised convincing arguments for ARPA retention of the program. As one of the participants in the transfer process noted, that process was terribly chaotic: "nobody had a clear rationale for anything.... [the atmosphere was] a combination of intuition, paranoia and emotion."[60]

What Dr. Rechtin brought to the situation was a clear voice in favor of a major, structured organization transfer -- people, programs, and money to be shifted intact. Prior to Rechtin's arrival, a combination of the SENTINEL decision, DDR&E disenchantment with ARPA and the Foster meeting may have made it clear that the core ARPA radars would go to the Army, either as part of the PRESS range or as part of the BMD development program, but the timing, what else would be transferred and the form of transfer were left unsettled. Rechtin had a powerful influence on crystallizing firm decisions and placing his weight behind a "smooth and unruffled transfer," and a transfer of considerably more than just the PRESS radar facilities. In fact, he was so intent on transfer that he almost "gave away the store" in the sense of being prepared to pass on more than ARPA staff thought he should or the Army expected to get. The great danger, of course, was that massive transfer of projects and funds in a single act would leave a hole in the Agency's program structure and budget that could not filled and hence might be lost forever. Rechtin's clarity of purpose and decisiveness were admired, even by those who disagreed with any transfer, but conditioned by a feeling on the part of many that he was bureaucratically naive and thus liable to do the Agency irreparable harm despite the best of intentions.

The reasons given by the new Director for supporting the form of transfer which occurred are central to the DEFENDER story and to the overall ARPA history. First, Rechtin accepted the view that ARPA did not have the organizational capacity to cope with future developments in the program which might logically be expected in the light of the SENTINEL decision:[61]

> ... I felt that that particular line of development had proceeded far enough. It was now going to be very expensive if it were continued... going to have to build enormous radars... going to get [into] the missile business without much trouble. And it was going to chew up a far greater portion of the ARPA budget than it already was. At the time it [the portion of DEFENDER transferred] was $60 or $70 million a year... [but one could easily] spend two or three times that in that kind of work. And that you were going to wind up attempting to build a competitor to what was then the SENTINEL system, later SAFEGUARD. And I could see that ARPA was going to get itself in trouble from two counts.... All the rest of its programs were going to get squashed on account of DEFENDER... and [ARPA would] get caught in the

> crossfire between 'why are you doing this one and the Army doing another one?'... I didn't feel that was good for either the Army or for ARPA. Particularly not for ARPA, because it didn't have the wherewithal to continue. It couldn't keep on building, and building, and building, and build a full-scale system. It had to transfer. It was getting to the point of where it was just too expensive.

A second reason given for supporting large-scale transfer was fear of involvement in the political conflicts which were certain to arise following the SENTINEL decision. Given ARPA's vulnerability in the late 1960's, involvement in the ABM policy battle could be fatal. ARPA, Rechtin noted, would be highly exposed and" ... for an organization that was about to be killed off ... with Deputy Secretaries not quite understanding what this damned thing is for anyway ... and with big giants around,"[62] this would be the height of folly. The major investments which would be involved in Sentinel would bring out powerful antagonists, and:[63]

> ... I used the old Russian proverb that if you're a clay pot don't get on the same stove with iron kettles. And ARPA's a clay pot. Very fragile.

In retrospect, Rechtin feels strongly that this position was vindicated:[64]

> It freed ARPA up to request more money for new things, which we promptly did, and our budget did not suffer the severe decline that people had worried about.... Then when the thrash snowed up with the Congress, and they really climbed all over the SAFEGUARD program, ARPA was free and clear of it.

Beyond Rechtin's doubts about ARPA being unable to sustain a continuation of the mainstream DEFENDER effort and his fears of being caught in the political cross-fire, he also shared many of the other reasons cited earlier for transferring the core program. Prominant among these was the feeling that the program was too mature to fit in with the traditional ARPA role:[65]

> [T]he problem is, where do you draw the line? At what point do you finally say: 'Well, ok, its no longer sort of relatively unrestricted for R&D -- you now have to do something a great deal more definite than that?

Rechtin had an answer: "It had long since gone past the early research feasibility phase."[66] In his judgment, and he was a supported of ABM systems deployment, it was time to get down to the drudgery of building a final weapons systems, and that was not an ARPA function.

In contrast to the transferred DEFENDER work, the strategic technology efforts retained by ARPA were later described to Congress as treating those:[67]

> ... advanced concepts and technologies that could have a major technical impact on the offense/defense balance and hence on the U. S. strategic capability. The assigned concepts include technologies distinctly different from those used in the SAFEGUARD system.

From Rechtin's perspective, therefore, the DEFENDER transfer and creation of STO fit nicely into the image of ARPA as a high-risk organization oriented toward technologies of potentially revolutionary impact.

Strategic Technology Office. The Strategic Technology Office, or STO, inherited the residual elements of the old DEFENDER program and the history of the office during the Rechtin period is one of the gradual development of a coherent program out of a rather diverse collection of projects. In the course of this evolution there was considerable budgetary change. The FY 1969 STO program budget was $98 million,[68] including the DEFENDER funds scheduled for transfer to the Army. Excluding the Army moneys and $7 million of supporting Lincoln Laboratory programs, the budget was $53 million. The FY 1970 request, however, was for almost $72 million and STO was given about $65 million (with one major project transferred from STO to Advanced Engineering). The following year's request (FY 1971) was $66 million, with $65 million again approved. This was increased to $72 million in FY 1972. STO thus stabilized at about two-thirds the level of the last DEFENDER budget, but at a level significantly above the immediate post-transfer residual level.

Forming a coherent program out of the remains of DEFENDER was not an easy task as the surviving projects had related to the core DEFENDER effort in widely divergent ways. During the Rechtin period STO retained a major part of the reentry physics program, which continued in its

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* As a postscript to the emotional DEFENDER debate, by 1971 or 1972 Foster was thinking seriously about reestablishing a very advanced ABM R&D program in ARPA, largely because: (1) ARPA's ability to attract and retain talent was better than the Army's, and (2) once one gets into a very large program [SAFEGUARD/SENTINEL], it eventually becomes necessary to give up the advanced research in order to keep the systems effort on-stream.

traditional measurements and analysis role, providing inputs to both offensive and defensive missile systems development. Rechtin was as keen as Herzfeld about this segment of DEFENDER:[69]

> The measurements program we kept in ARPA. The offense versus defense question was retained in ARPA. And I felt that was right. As a matter of fact it expanded back up to $70 or $80 million. I felt that was absolutely essential. ARPA was the only place in Defense that had credibility as a neutral. And that's one of its principle [reasons] for staying there. Also, in that argument, you didn't have to get into the extra-ordinarly expensive full-scale development. It could be doing all those things to determine the basic parameters of that kind of a conflict. And that was very important, and I felt that Dave Mann... and Kent Kresa and the other guys who worked in that gang, I thought did a fine job [to] find out the basics....

STO also kept the truly exotic weapons concepts, such as charged particle beams and lasers; it retained some radar work (notably OTH) that was not directly relevant to NIKE-X type systems; it continued optical measurements programs (and retained the AMOS facility); and it sustained institutional support programs in atomic and molecular physics.

One of Rechtin's managerial exercises involved an attempt to think up potentially worthwhile "new directions" for ARPA R&D, and ARPA also was aware of a similar sort of activity with a DOD-wide focus which Foster had commissioned a committee chaired by Simon Ramo to undertake. Some of Rechtin's choices found their way into the STO program. One of them involved the addition of work in "advanced marine technology," including a Rechtin initiative to develop large floating platforms for military use.

As stated by both Rechtin and the program director, Dr. David Mann, the early STO program was a collection of "cats and dogs" lacking a central mission focus, and it remained so throughout much of Rechtin's tenure.[70] Over time a rationale did develop, what Rechtin calls "a rebalancing to go after the basic physical techniques which would give you the answers for offense/defense confrontations."[71] In other words, the STO rationale tended to replicate the penetration aids versus missile defense characterization found in DEFENDER after 1961.

<u>High Power Lasers</u>. Of all the programs inherited by STO from DEFENDER, the most excitement was generated by developments in the field of high power lasers. As previously noted, renewed interest in lasers for weapons

applications had been kindled during the Herzfeld period with breakthroughs at AVCO-Everett in which the use of rapid flowing gases as a lasing medium was demonstrated to be a practical approach toward overcoming the power limitations inherent in solid state devices; however, power outputs in the multiple (but less than 100) kilowatt range were achieved only toward the latter days of Herzfeld's tenure, so that Dr. Rechtin (arriving in late 1967) inherited a program just beginning to show substantial payoff.

There were a number of major developments in the high power laser field in Rechtin's first year. Research in this areas was reviewed by both ARPA and the Defense Science Board in mid-July, leading to an expanded program of ARPA support, in part because Foster found that he could not get it going outside of ARPA. This program, which was to more than double ARPA's laser investment, was initially a highly secretive, limited access effort known as EIGHTH CARD. Reflecting contemporary feeling about the importance of laser developments and the threat of competing foreign efforts, even the term "gas dynamic laser" (GDL) was originally closely guarded. These strictures have long since been dropped and discussion of technical developments now regularly fills the trade press. The flavor of urgency and importance accompanying this "special" project, however, gave the effort particular status within DOD and, according to Dr. Foster, helped prod dormant Service interest in the technology, i.e., the secrecy surrounding EIGHTH CARD, to which they lacked access, probably did more than anything else to stimulate them to do something. Foster, fearing a possible Soviet breakthrough, strongly promoted laser work, reaffirmation of a sort that an ARPA still looks useful in times of stress, but also testimony to the fact that we still tend to drive R&D programs on the basis of what somebody thinks "the Russians are doing" or not doing. Rechtin echoed Foster's view of the laser work: "We've made sure that [neither] the Soviets nor anybody else is going to surprise us there. That was important."[72]

By Dr. Rechtin's second year in ARPA, 1969, the program was clearly established as one of the priority ARPA efforts, and success was reflected in Dr. Foster's initiation of a Tri-Service Laser (TSL) program in February of that year. This program enabled each of the Services to build an experimental device and to pursue potential applications of the new technology utilizing ARPA/AVCO advances (AVCO being the TSL contractor). In addition to the new Service programs, with which the ARPA effort was closely coordinated, there were further demonstrations of advances in GDL power output capabilities in 1969 to the hundreds of kilowatts level, with major developments at AVCO and at United Aircraft (which had initiated a program somewhat parallel to the AVCO effort and had attracted ARPA support by 1968). Moreover, important new advances were achieved in electric CO_2 lasers and in chemical lasers, both of which shared the high power potential of the gas dyanmics deveices and offered other technical advantages affecting size and weight and other aspects of the devices.* Toward the end of the year advances in these new types of high power lasers seemed sufficiently promising that ARPA decided to reorient its program entirely away from further development of the GDL (which was left largely to the new Service programs) and toward emphasis on electrical and chemical devices. This new emphasis continued throughout Rechtin's last year (1970) and into the Lukasik period.

It should be noted that throughout this period of very rapid development in high power lasers, only a portion of the ARPA effort was devoted to actual construction of new devices. A high percentage was directed to theoretical studies and to experimental studies with lower powered lasers which helped lay a basis for predicting the operation and limitations of more powerful devices. Laser technology, it should be emphasized, involves very complicated interactions within the laser device, between the laser beam and the atmosphere, and between the beam and the target, as well as extraordinarly difficult problems of pointing and tracking. Much of the most influential ARPA work was therefore in studies concerning laser materials, propogation characteristics, plasma effects, etc., rather than in prototype hardware development, although the achievements of experimental devices provided dramatic demonstrations of technological advance.** The ARPA effort was, however, a very broad-based technology development program.

ARPA's laser program during the Rechtin period is considered by many associated with the agency as exemplifying the ARPA role at its best, i.e., in supporting high-risk, high-payoff research and exploratory development. Within the short period of three years, ARPA injected major support into two firms (AVCO and United) which had initiated promising, highly Defense-relevant, technological developments; organized a comprehensive program which extended considerably beyond the initial contractors; served as a focal point for Service interest and a take-off point for major Service programs; became the organizer of a new technical community (sponsoring numerous reviews, meetings and conferences); avoided

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* Discussion of the complicated distinctions, advantages and limitations of the three types of devices, and various combinations of them, is beyond the scope of this report. For a layman's review, see the Aviation Week series on lasers in the issues dated August 25, September 1 and September 8, 1975.

** Interestingly, one of the major technical problems in developing practical laser weapons surrounds the need for advanced power sources and energy conversion devices, including fuel cells, batteries and MHD devices, a field given significant support by ARPA in the early 1960's and then phased out, partially due to lack of sufficiently pressing military requirements and partially due to funding limitations.

over-commitment to building devices based on available technology (toward which there was considerable pressure); and, finally, shifted direction from the GDL technology which had attained spectacular initial successes but had several serious limitations, to newer and potentially even more promising concepts (electrical and chemical lasers). The latter decision to shift technological emphasis (made at a late 1969 meeting of experts in Palm Beach) is regarded within ARPA as a fundamental watershed in the high power laser field.[73] Taking this decision appears to have required some courage, as it entailed abandoning an emphasis that was highly successful and at the height of its popularity -- and which if technically "old" had become so in only one or two years of major support -- in favor of new, much higher-risk approaches.

By the end of his tenure, in short, Dr. Rechtin could view the laser program as perhaps the example of what a good ARPA project should be. Cited by a DDR&E advisor as "the beginning of a revolution in military weaponry," it met his criteria of defense-relevance and high-payoff development of far-reaching significance. In terms of transfer, he could show vigorous programs based on clearly identifiable ARPA-supported technology established in not one, but all three Services. There was no question that the program involved very advanced technology and was initially a high risk endeavor where the Services had not, by themselves, been able to make the early critical investments. ARPA had, moreover, successfully moved on to new developments of potentially equal significance to replace the emphasis taken over by the Services and remained on the forefront of the technology in question. The laser program, however, appears to stand virtually alone among major ARPA programs of the late 1960's in fulfilling all the Rechtin criteria for a successful project.*

Nuclear Monitoring Research

The style and emphasis of the Rechtin directorship is especially well-illustrated in the field of nuclear test detection, particularly his concern with program turnover and transfer. In this program area, the new approach was reflected in both matters of image and of substance.

* Although little was said about this in the ARPA of the late 1960's, ARPA had stuck with laser work since 1958, and according to one of the giants in the field -- Charles Townes -- its very early support at the basic research stage, when no one else would touch it, was more critical than anything ARPA did subsequently.[74]

The VELA satellites were an obvious candidate for transfer and that did occur. Foster and Rechtin were also prepared to pass on much of the underground detection program to the Air Force, but failed:[75]

> The difficulty was that was not a normal Air Force mission, and, therefore, every time it was tried in reasonably good faith, it wound up getting in trouble again because of the funding, or the people wanted management support, or whatever. It wasn't inherently there. I don't know what you do about that kind of situation.

In addition, there were external forces that mitigated against transfer out of ARPA: (1) DOD was more or less legally charged with doing the work and OSD/ARPA had been the designated assignee, (2) there was a complex intergovernmental scenario to consider, involving many agencies, and (3) "Congress wanted to make sure that we did everything possible to permit further reductions in weapons types."[76] Foster knew that if he transferred this program to a Service or seriously reduced the budget, the arms control community would be upset:[77]

> So we carried it [the program] at a higher level of funding in deference to them, than we otherwise would have.... ARPA's flexibility, adaptability and penetrability enabled it to execute the program with the requisite degree of responsiveness.

Foster and Rechtin were thus unable to cut back here as much as they wished.

It should be made clear that Rechtin was not unhappy with VELA's accomplishments and was not opposed to the princple of looking at improved means of detecting nuclear tests. The issue with him, as in DEFENDER, concerned whether the "research feasibility" task had been completed:[78]

> In terms of a continuing look at the problems of detection and evasion, I felt that should continue until there was a political conclusion as to whether or not we had gone far enough. I had no emotional involvement with that issue myself. I felt that conceivably it was possible to get to the point of evasion and detection where you knew enough of the rules and you were sure enough of the answers that you could put a

> limit, if you wished, on the size of underground nuclear explosions. And the reason that that might be possible is because the risk of getting detected was so much more of a problem to the attempted evader then it was to the detector; that there was, if you will, high leverage in that kind of a situation.... So I felt that conceptionally you ought to be able to reach a point eventually where you were satisfied if you wished to put a comprehensive test ban on, that ARPA would have provided enough information to tell you roughly what the risks were likely to be. From there on, as far as I saw it, it was a political problem and not a technical problem. We were almost to that point when I left.

There were three important developments in the Rechtin period with respect to the image of ARPA's nuclear test detection work. First, the office was renamed Nuclear Monitoring Research, replacing the former Nuclear Test Detection title. The new title implied a broader mission, e.g., research on evasion, diagnostics, etc., rather than a focus on test detection only; however, in fact many of these broader missions were actually included in the program almost from the beginning. Important research on evasion techniques such as the use of decoupling was, for example, undertaken in the Ruina period. Second, the title VELA, which had formerly been interchangeable with Nuclear Test Detection was dropped for this purpose. Work identified as VELA was merely part of the activity called Nuclear Monitoring Research. This occurred at roughly the same time that AGILE was dropped as an overall code-name for the Overseas Defense Research Office and relegated to the position of a subordinate program element. The intent in both cases was apparently to reduce the visibility of these aging assignments and to give the appearance of program dynamism and change. Third, a new program element entitled "PRIME ARGUS" was formed within the Nuclear Monitoring Research office. It was not only added to the VELA mission but was actually considerably larger -- in FY 1970 the request for PRIME ARGUS was $24.5 million out of an office total of $38.5 million. PRIME ARGUS essentially encompassed everything outside of the nuclear test detection mission, narrowly defined.* It included, notably, research on evasion (or "detection countermeasures"), nuclear test diagnostics, research related to nuclear weapons proliferation, and a new program in "military geophysics." While, as

* Subsequently, the scope of PRIME ARGUS was reduced to essentially diagnostics related research, and other program elements originally included under the title were presented separately.

previously noted, significant work in some of these areas had been performed prior to Dr. Rechtin's appointment, the Rechtin emphasis was clearly on newness rather than continuity and the various changes in titles all served to underscore this emphasis.

This is not to say that there were no important substantive changes within the Nuclear Monitoring Research program. Three major points can be cited. First, the degree of emphasis on evasion of test detection was increased over previous years. This included further development of cavity decoupling concepts, research based around the "Diamond Dust" physics experiments (using 10-20 ton nuclear explosives and examining decoupling in various media other than typical "tuff" or hard rock), and research on other evasion technique such as earthquake simulation or hiding a test during earthquakes. The effect of this work on evasion (quite aside from the question of DOD motivations) was to generate new questions concerning the reliability of safeguards and detection techniques which might be applied to a future ban on underground testing. It appeared to be part of a general trend toward narrowing the boundaries of risks deemed tolerable if a Comprehensive Test Ban were to be acceptable. According to Dr. R. A. Frosch, VELA Director under Sproull and Deputy Director to Herzfeld, perceived requirements for seismic detection thresholds began to be tightened shortly after the signing of the Limited Test Ban Treaty, and increased attention to evasion possibilities served to further restrict the boundaries of "tolerable risk."[79]

Second, there was a considerable shift of emphasis toward "diagnostics," that is, toward methods of determining the characteristics of a nuclear test (yield, type of device, etc.) as opposed to simple detection and identification. This change had begun earlier with the initial success of the VELA Satellite program and its subsequent reorientation, but the Rechtin period established diagnostics (through PRIME ARGUS) as a major formal mission. The customer for diagnostics research results, incidentally, was more the intelligence community than the test ban negotiations community and the program reflects a general shift of emphasis within ARPA toward intelligence-related technology.

Third, the Nuclear Monitoring Research office phased-out one major program (VELA Satellite) and added a major new one (Military Geophysics), for which $7 million was requested in FY 1970. The VELA Satellite had long been serving in an operational as well as a research role and discussions had frequently taken place with a view to passing responsibility to the Air Force for use in the interim period prior to its replacement with a "permanent" satellite detection and diagnostics system. Given Dr. Rechtin's emphasis on project transfer, the VELA Satellite effort was a very logical candidate to be phased-out and was in fact so transferred. Unlike the DEFENDER effort, however, the major investments in the VELA Satellite effort had already been made (the main continuing effort being data monitoring and analysis) and the transfer caused little budgetary perturbation.

The new program, Military Geophysics, essentially had nothing to do with nuclear testing. It involved research on the conditions, characteristics and ultimate control of earthquakes. According to Rechtin the program was undertaken for that most traditional of ARPA reasons -- "other people weren't doing it" -- and was justified on an alleged military requirement for "a cost-effective way of reducing earthquake damage to the billions of dollars of defense installations in seismic areas."[80] It was established within the Nuclear Monitoring Research office as a means of utilizing related technological expertise developed through the underground test detection program. The record suggests that it developed in part as a response to the frantic need for ARPA to find things to do. As will be discussed below, the program ultimately failed to gain Congressional support as a sufficiently unique military requirement and the House Appropriations Committee requested and obtained its deletion (along with a related program in "rapid excavation") from the FY 1973 budget.

Overseas Defense Research (AGILE)

Dr. Rechtin came to ARPA with considerable interest in the AGILE program, gave it continued and detailed personal attention throughout his tenure to the point of being considered by senior associates almost as an AGILE program officer, and is generally associated with being a proponent of AGILE, though in retrospect he shares the generally prevailing negative view of AGILE's impact. In some respects, Rechtin was a throw back to Godel and Herzfeld. He felt that research on insurgency problems was a good idea and he much preferred the mission of working with local forces to trying to work with U. S. forces:[81]

> I felt pretty strongly that we were supposed to be working with the other countries. We could, occasionally, provide help to the American forces by telling them things that we were learning so that they could be more effective as American forces.... The principle effort, by the time I was there, was aimed at helping the Vietnamese and helping the Thai and helping the Iranians, rather than the American forces directly.

Rechtin's assessment of the balance of effort is probably only correct if viewed in light of the major expenditure of funds on the RSSP in Thailand that started-up about the time he took over. The Thai, however, saw that exercise as less relevant to their concerns than many things done previously, and compared to AGILE's original, almost exclusive preoccupation with indigenous forces, AGILE in 1967 was heavily weighed in the direction of U. S. Vietnam-related needs. The sheer force and weight of the U. S. presence also often was enough to distort the value of some of the things AGILE originally had in mind to assist indigenous forces. One of the Thailand field unit directors observed cogently that while ARPA was struggling with the problem of communications in an environment where one assumed obvious practical limitations on the resources that would be made available to the local forces using the techniques and equipment developed, the U. S. Army came along and transformed it by means of massive infusions of funds into the world's richest communications environment.[82] Thus, however successful ARPA might be in getting a good data base, developing and testing a theory, showing the physical aspects of a couple of new modes of propagation, and trying to extend this to, say, a battalion-level model, it became irrelevant. A tricky new form of line-of-sight communication became rather absurd when the U. S. Army was doing it simply by putting beacons on every hill in sight, regardless of cost.

Nevertheless, Rechtin was more interested in local forces. He also felt that ARPA, one way and another, had learned a philosophical lesson of signal importance during its sojourn in Southeast Asia:[83]

> I think we were perhaps some of the first to show that in Vietnam that you had to get the war back to the Vietnamese forces if you were going to have a chance. That you weren't going to be able to win it with American forces. And if your objective was to win, it had to be done with Vietnamese forces, and if they couldn't win, you'd had it. And I thought they could. But I thought we goofed.

To the extent ARPA was right and sought to relay this message, the greater were its difficulties because "bad news" was not encouraged in those days; nor was ARPA's credibility such that it would likely be taken at face value even if high level listeners were predisposed to listen. Nonetheless, Rechtin believes that creation of the climate which enabled Kissinger to negotiate the U. S. withdrawal was in some sense helped by ARPA or at least was a vindication of some of the things ARPA was saying:[84]

> Because we had a much better understanding of what we could and couldn't do, because of what had been found out. It took a long time to permeate from where ARPA had its answers until the rest of the community understood some of these things.... It [ARPA] was one of the many influences which tried to tell us what you might be able to do and what you weren't going to be able to do.

A somewhat more harsh assessment would suggest that perhaps many of the "lessons" allegedly learned by ARPA as to what could and could not be done were known at about the time AGILE was created and thus raise the question whether ARPA spent tens of millions of dollars on rediscovering those lessons instead of applying those resources to a more direct search for solutions. This was indeed an area where ARPA and many others were limited by ideas not funds and tried unsuccessfully to compensate for the former with a generous application of the latter. Rechtin, however, had inherited a large active program and coming to the problem new, under that circumstance, addressed himself primarily to results, not philosophical questions concerning the program's origins and evolution:[85]

> We tried to work the counter-insurgency business at that stage and found we couldn't be very effective in doing anything. Mostly because systems engineering, with all of it's value, couldn't really be very effective when the principle parameters were those of nationalism in a counter-insurgency situation.... Local nationalism ... was the principle counter-insurgency force as it turned out. And all the things that we tried -- radar systems and boats and whatever -- were nowhere near as important.... But I thought it was a good idea for ARPA to try. I defended it strongly, put money into it, tried to get it going, ... [tried] to get it transferred over to the other countries, where I thought it would be better done than the U. S. trying to do it.... You learn by seeing what you can do and when you can and can't help. I thought it was a good risk project.... Maybe the success ratio was 50/50.... Maybe 30% success and 70% non. But that's what ARPA is in the business of doing. Hell, if it was obvious the Services would have been doing it in the first place."

Foster volunteered similar recollections, noting that ARPA provided ways, means and a location so that "concerned people could try.... ARPA surfaced some messy problems and took its lumps."[86] He felt that ARPA-sponsored ethnographic studies and its attempts to deal with political, military and social problems together were helpful. Confirming both Herzfeld and Rechtin, Foster noted:[87]

> ARPA studies had very different views of the war than those held by the Secretary, the Deputy Secretary and the White House -- and those views were painful, but in retrospect they were helpful.

To illustrate Rechtin's support for the AGILE program, budget increases were proposed in the face of substantial Congressional skepticism and outright hostility. Indeed his FY 1970 Overseas Defense Research budget request was $29.4 million, up from $27.4 million the previous year. By contrast, the House Appropriations Committee recommended a $26 million reduction in the total ARPA budget, a "significant portion" of which it directed specifically be assessed against the AGILE program. This episode spelled the beginning of the end for AGILE, which rapidly disintegrated thereafter and left only a small legacy of projects to be absorbed into a new Tactical Technology office formed during Dr. Lukasik's tenure. Rechtin confirms that anti-AGILE pressure from the Congress and the Secretary became overpowering.

The AGILE program which engendered all of this controversy was largely inherited from Dr. Herzfeld's regime. The program continued to be dominated by work in Southeast Asia in the Vietnam and Thailand field units. As in the preceding period the work program included "quick-reaction" studies in Vietnam, an "applied behavioral sciences" component, a major counter-insurgency "systems research and development" effort (notably the Rural Security Systems Program in Thailand), and a variety of hardware development projects, e.g., work related to reconnaissance and intrusion detection devices. Research related to border control problems gradually received increased emphasis, whereas behavioral science and "systems" research received decreased emphasis as disappointing results, organizational problems and Congressional criticism began to dominate program discussions.

In response to program controversies, decreased prominence was given to the name AGILE. It was gradually replaced by the more mundance phrase Overseas Defense Research. Less inherently controversial projects also began to be given the spotlight in program descriptions, e.g., border control work in Korea, where the national commitment was less in question; the Small Independent Action Force (SIAF) project, which looked at improved ways to organize small unit patrols to maximize effective use of modern small arms technologies; some work on counterpart training, in hopes of being responsive to the Nixon Doctrine; and more U. S.-based, rather than field-based, research in general. Some of the projects selected were more or less desperate attempts to find acceptable things to do and/or to keep staff and contrators employed. There was little in the way of a coherent program goal or target around which to structure them.

Rechtin always felt that ARPA was correct in trying to do something about insurgency:[88]

> [I]t was a perfectly appropriate thing for ARPA to do. I think it was right for it to get set

> up... and I think it was right for it to do the work that it did do. It was a rough, miserable, dirty kind of an area to do research in. Somebody's got to do it.... The return on the investment, I would say, was at best modest. But ARPA was not in the business of trying to get maximum return on investment. Geez, if you're trying to do that, you're doing things that are certain. And we were doing things which weren't.

These remarks help to shed some light on an important problem within ARPA during the Rechtin period. Morale was often very low. The Foster/Rechtin whirlwind was rapidly trying to transfer out core programs such as DEFENDER, VELA and Materials, yet they were not communicating very clearly to the staff what sort of an ARPA was to replace the old one. The hard gospel of obvious relevance, quick programmed transfer and minimization of basic and applied research simply failed to match up well, in the minds of staff, with statements that ARPA was not in the business of getting "maximum return on investment" or in trying to do things that were certain. There was a definite feeling of drift, confusion, and frustration, which in turn made the Director's task of preserving ARPA all the more difficult.

Rural Security Systems Program. The Rural Security Systems Program (or RSSP) was, like SEACORE and MERS, a large Thailand-based AGILE endeavor. Like them, and probably even more so, the effort is widely regarded as a failure and illustrates the continuing difficulty encountered by AGILE in developing a workable rationale for its Southeast Asia field research activities. The RSSP concept was developed during Dr. Herzfeld's period as ARPA Director, but commenced in Thailand a few months before Dr. Rechtin's arrival. For about two and one-half years (early 1967 through late 1969) the program was a dominant feature of the Thai field unit. By the end of 1969, however, Rechtin dispatched instructions to phase out the RSSP projects. This event marked the beginning of the disintegration of the Thai field unit and ultimately the entire AGILE program.

The RSSP effort was an internally-generated ARPA program, the idea having been developed by a Washington-based project manager sometime in the 1964-1965 period. The basic concept was that approaches to the resolution of insurgency, by the military and others, tended to be narrowly-conceived partial solutions and that what was actually needed for successful "counterinsurgency" efforts was a broad-gauge "systems approach" to the problem. This concept, which by analogy related counterinsurgency to systems engineering approaches felt to have been successfully applied to strategic weapons problems, struck a very sympathetic chord in Dr. Herzfeld who, even in the 1970's, looks back on the approach as a valiant (though admittedly unsuccessful) attempt to rationalize the counterinsurgency problem, and who regards the overall concept as essentially correct.[89]

Virtually everyone in ARPA with Southeast Asia field experience at the time considered the RSSP concept as originally presented to be a sham, a rather gross form of charlatanism, or what Godel calls "fiddle-faddle." The originator had strung together some systems jargon, but there was relatively little substance in the proposal and there were some exceedingly dangerous assumtpions. It was, for instance, assumed that a flow of first class information about the social, political, economic, attitudinal, and personal proclivities of villagers in large rural areas would be readily forthcoming, when in fact ARPA field experience in Vietnam and Thailand was already showing that it was exceedingly difficult to obtain such information and that without it, no "system" could hope to survive. The RSSP was doubly fallacious because it helped sell itself in a public relations sense by claiming that it would solve the "soft science" side of the equation. It had no substantive concept for doing so; it merely assumed that a solution would be forthcoming from one or another as yet unidentified contractor group. Nevertheless, systems engineering was in vogue in the mid-1960s and the notion of systematically integrating all aspects of the counterinsurgency problem into a comprehensive whole had immense appeal, especially to an ARPA leadership that had cut its teeth on resolving such difficult technical problems as defense against ballistic missiles, nuclear test detection and enhancing the penetrability of ICBM warheads. At last technical elegance and sophistication would be introduced into a research area heretofore characterized by conceptual shortcomings and ad hoc stabs at the problem, and it would be done in Thailand where the insurgency was relatively low level and hence suitable as a laboratory. As Herzfeld told the Congress: "This program will be the first time that R&D has been given a major role in supporting a counterinsurgency in a comprehensive way, from the earliest stages of the conflict."[90] The appeal of this vision was irresistible.

The RSSP initiative was gradually transformed into a program following an extensive series of briefings in 1966, through which approvals and concurrences were sought from the Deputy Secretary of Defense, key Assistant Secretaries, JCS, the U. S. Embassy in Thailand, the Department of State (and USIA and AID), and the Royal Thai Government. The U. S. approvals were obtained by mid-year and the Thai government, under pressure from the Ambassador, "approved in principle" in November 1966. In late 1966 the AGILE Director wrote the first year RSSP plan and contractors began to initiate work on approved projects at the beginning of 1967, just prior to Dr. Herzfeld's departure. The Thai government, having approved the RSSP only in principle, reserved the right specifically to approve each individual project conducted.

As finally developed, the RSSP was to employ a form of systems analysis to integrate and program all aspects of a counterinsurgency effort in Northeast Thailand, an effort which would comprehensively include military and police action economic and political development, civic action, and so forth. Several large U. S. contractor teams were to undertake aspects of the program. The RSSP "system" was frequently briefed as consisting of four subsystems -- border control, village security, security-related economic development, and "extending government in rural areas."* The program hoped to demonstrate, through influence on actual counterinsurgent operations in Northeast Thailand, that such a "systems approach" and various R&D products and techniques could enhance the capabilities of indigenous forces and, indeed, "solve" the counterinsurgency problem. As by-products, the RSSP would assist in Thai counterinsurgency training; strengthen the role of Thai military R&D in the government's response to its security problem; provide data and lessons for counterinsurgency planning elsewhere; introduce greater consideration of social science inputs in counterinsurgency planning; etc. In addition, by obtaining overall approval for a broad program it was hoped that the ARPA field unit would have greater flexibility in conducting its research, and in part overcome the project-by-project approval chain through CINCPAC, and that this would enable the research to have greater impact.

In fact, however, the above objectives were vague, subject to considerably varying interpretation, and not necessarily mutually reinforcing. Considerable conflict developed, for example, over who should be the primary users of various outputs of the RSSP projects: the MRDC, various operational arms of the Thai government, the AGILE staff itself, the U. S. Embassy (which had a special assistant for counterinsurgency matters) or others. The projects undertaken within the four "subsystems" (and efforts more generally supporting the RSSP) actually emerged as quite particular and distinct efforts with much less program integration

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* For briefing purposes, graphics were used to portray the RSSP as a Greek temple with the four subsystems noted being the pillars of the temple. The program was presented for the first time to two senior ARPA officials placed in Agency leadership positions in mid-1967, using this simple graphic. They (both physical scientists) were appalled and amused by the naivete and pretentiousness of the device, according to one's recollection of the event. They subsequently concluded that the program was a disaster. Later, the Thai were encouraged to duplicate this kind of "systems" thinking and presentation, with an amusing sidelight being one Thai military officer's development of a similar graphic in which aspects of counterinsurgency were portrayed as parts of a large chicken.

than was implied by the RSSP rubric. Even the geographic focus of work was ill-defined, with the program initially conceived as concentration on a single "test" province, then directed toward Northeast Thailand as a whole, and ultimately involving a variety of efforts in other parts of Thailand as well. The contractor groups involved were often of marginal quality and were hard to control. As AGILE staff problems arose in managing the effort, a decision was made to contract for a "research and planning group," to serve as the basic "controller" overseeing all the other contractors. The firm selected was never able to fulfill a central planning and management role and ended up doing a few additional specific projects.* During this phase, ARPA's Deputy Director was sent to check out some of the indications of serious problems in RSSP and he recalls finding that "not only was it laughable ... it was really bad."[91]

Of the RSSP projects funded, two were basically data collection and documentation efforts (a handbook on the "test" province, and a series of manuals describing counterinsurgency and development programs in the country); one was an information system which identified and located villages and proposed a system for recording reports on insurgent activities (which could be used in conjunction with the village data); three concerned "systems" for border control, village security and village alarms. All of these projects were skewed in very particular directions in order to accommodate the desires and reservations of the individual agencies -- Thai and U. S. -- with which they interfaced. None of them in retrospect, gained the reputation of being particularly well done.

Many aspects of the RSSP were regarded as extremely sensitive by the Thai, e.g., the alleged need for provincial political reform and issues concerning villager attitudes and motivations. Accordingly projects were often constrained and activities were approved slowly and often reluctantly. The issue of the legitimacy of U. S. involvement in Thai internal affairs, which was implicit in the RSSP program, was a real one. It is perhaps symbolic that the U. S. contractors for the RSSP were physically located in an entirely separate building across town from the Thai-U. S. MRDC with which they were supposedly integrated in a joint program.

Herzfeld was frustrated by the long approval cycle that preceded initiation of RSSP, and in retrospect, he believes that personal antagonisms and rivalries helped undo the idea -- the former (the approval

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* The group had little prior Thailand experience, and was in natural conflict with other contractors, some of which had field unit experience going back several years.

cycle), of course, provided considerable scope for the latter:[92]

> [A]s I recall, there was something like a two-year cycle of paper circulation. Nothing happened except paper circulation. And even though we had a number of face-to-face meetings in various places and at various times, to straighten [it] out, it always got back to 'no, let's [do this or do that].' Somebody had a different concept and that concept was reintroduced. I think it was the competition among people, and I hold various individuals responsible for that, including myself, who were more interested in their own ideas than the program. That's what finally killed [it].

The development of the RSSP program, added to existing AGILE programs in Thailand, combined to make the Thai operation approximate a $10 million a year level of effort during the first two years of Rechtin's tenure (of which RSSP was perhaps half). Due largely to the RSSP, therefore, the AGILE program in Thailand was highly visible and exposed, in part because of the budget and in part because of the controversial nature of the effort.

Dr. Rechtin's stance on the RSSP program is not altogether clear. He saw numerous problems with the effort in Thailand, as in other areas of ARPA work, but viewed the then current AGILE program director as an interesting theoretician, and in retrospect he views the RSSP experience as an experiment worth doing:[93]

> [W]e made an assumption that you could apply system reasoning to that kind of a problem. And ... it didn't work. I think we know why it didn't work and as such, I thought ARPA did a credible job. The reason it didn't work was because: (a) there were too many variables, and (b) we couldn't control them.... It turned out that although we had some very interesting ideas... the total system couldn't be defined and it certainly couldn't be controlled.... And as I said, I think we essentially proved that analytic techniques of themselves -- system design techniques -- in practice can't be worked. It's an interesting idea to go through, but you find a lot can't work like that.

Despite some serious reservations, notably with the management of AGILE programs, the RSSP was allowed to continue well into 1969, when Congressional hostility and budgetary cuts made the effort unsupportable. In the meantime, however, a new Thailand field unit director, Dr. Philip Worchel, was appointed in March 1968. He did not support the RSSP effort, but was rather a vigorous advocate of basic social science research, a position at least as controversial and politically difficult in Thailand at that time as the RSSP.

Throughout the Rechtin period, therefore, the RSSP was in a practically impossible position. It was the major component of an unusually large field office focussed on the most controversial foreign political-military problem of the decade. It had been supported by an ARPA Director now departed, had developed its major projects during the absence of a permanent ARPA Director, and was inherited by a new ARPA Director quite skeptical of past Agency performance. At the same time the program was "entrenched" in terms of having completed numerous arrangements with Thai and U. S. agencies necessary to allow projects to proceed, had perhaps a hundred U. S. contractor personnel involved (plus numerous local Thai hires) and had numerous tasks and projects in process in the field and in the U. S. In addition, the field unit had a new director who disliked the program and the Washington-based originator of the RSSP had long since separated from the program. The "systems approach," moreover, had always been vague and any integrated approach had been undermined by compromises needed to sell specific projects. In the meantime, there was enormous turnover in the U. S. Embassy, ARPA field unit and contractor personnel and in Thai counterparts. RSSP became, in short, a large, disorganized, very vulnerable effort. It's collapse in the face of the Congressional attack described earlier was thus virtually inevitable.

<u>Review of AGILE's History</u>. Looking back on AGILE as a whole, Herzfeld believes that the AGILE approach to insurgency problems was basically correct, but that the war became too military in nature, too fast, and with too much direct U. S. military involvement; hence "events moved against the stream of the ARPA approach." ARPA believed in "countering insurgency," not in fighting a conventional war, yet the war became more like a true battlefield and less like an insurgency:[94]

> So, AGILE was an abysmal failure; a glorious failure. When we fail, we fail big. I still think we were right, but it was a failure [again, most because events passed ARPA by].

For purposes of perspective, a flashback to the creation of AGILE is useful. Godel was very sensitive then to the fact that the Geneva accords limited the U. S. to 700 military in Vietnam. This was a favorite take-off point in his early explanations of AGILE. Assuming that the U. S. lived by those ground rules and Americans did not get involved in large numbers, the problem very simply was what could you do for the locals and the few Americans:[95]

> The law said 700 Americans, and they were there 1954-1961, and they were at war. [The problem was] to figure out how 700 Americans should win the war.*

Godel wanted AGILE to help find the answers and to record the results. This is how the issue was structured in his mind:[96]

> Winning that war, at that time, in those circumstances, and have a legacy at the end -- a model of workable answers for the 'next time'.... [H]ave a package to show the Secretary and the JCS that this is how we did it.

Obviously the original ground rules changed, but even before they did Godel had his doubts about AGILE's outcome, in terms of the progress he wanted to achieve. He concedes a few minor accomplishments, but no successes of the type or on the scale initially envisioned. His final evaluation is deeply tinged with disappointment:[97]

> We never learned how to fight guerrilla warfare and we never really learned how to help the other guy.... We didn't do it; we left no residue of good will; and we didn't even explain it right.... Things [still] don't work in Asia, we [still] don't know how to communicate, we don't know how to secure a perimeter, and so on [short of fielding an entier U. S. army]. We did a goddamn lousy job of solving those problems, and that did happen on my watch.

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* AGILE has often been criticized for ambivalence regarding its objectives -- to work for U. S. forces or to work for indigenous forces -- even prior to the massive American entry in the Vietnam War. Godel always believed that the AGILE work should be directed at the local forces and the small groups of Americans who he anticipated would be operating with them. He assumed that the latter would be involved in infiltration, "drop-ins" and other limited engagements as well as in training functions. This undoubtedly was a source of some of the confusion about AGILE that subsequently emerged.

AGILE came the closest of any ARPA program to matching the intense missionary zeal of the early space program assignment. Both involved more passion and panache, at least for a time, than any of the remainder of ARPA's assignements and the two of them encapsulate the first and the last of ARPA's "Presidential issues."

Advanced Sensors

The Advanced Sensors program, with its obvious applications to the intelligence community, continued to be one of the most, if not the most, sparsely described areas of ARPA activity throughout the Rechtin period. Dr. Rechtin's immediate predecessor (Dr. Franken) in fact recalls that even from his position as Acting Director of ARPA it was most difficult to understand the program, since special clearance requirements inhibited even his access. The core effort of this office was thus publically described in such non-revealing terms as the following (Foster FY 1969 testimony):[98]

> The advanced sensors project supports research in such fields as acoustics, electromagnetics, optics, biology and chemistry that have important applications to new and advanced sensor concepts and hardware....

What does stand out in the Rechtin period, however, is the considerable reorientation of the advanced sensors program toward Vietnam-related combat and intelligence requirements. Foster noted in the above testimony, for example, that the project supported "quick-reaction type programs to meet specialized requirements of the war in Vietnam." During FY 1969, there was a major budget reprogramming action which brought the total program to over $27 million (from some $14 million initially requested by Foster and $17 million budgeted in FY 1968) with the reprogramming action justified as "to permit the accomplishment of additional Advanced Sensors R&D for the Vietnamese war." Advanced Sensors thus became practically as closely tied to the fortunes of the Vietnam conflict and Congressional attitudes toward it as did the AGILE program. Advanced Sensors' budgets, as noted, rose to a level approaching $30 million in the late 1960's, only to nose dive along with the AGILE budget in the early 1970's, and both programs ultimately shared the same fate of collapse and merger into a new Tactical Technology office in the Lukasik period.

The most visible of the Advanced Sensors programs of the 1960's was a Vietnam test effort involving mounting reconnaissance sensors, and in one version remotely-fired weapons, on drone helicopters. This program undertakes at ARPA initiative, was known in its various configurations as Nite Gazelle or Nite Panther. It was described in unclassified terms as follows:[99]

> The conventional technique for destroying trucks and other comparable military targets in Vietnam is to employ manned forward controller aircraft, high performance strike aircraft and large, relatively accurate bombs. It appeared worthwhile to see whether a quite different approach might not be more effective, using relatively small, properly equipped drone helicopters. An existing, remotely controlled drone helicopter (QH-50) was equipped with a real time day-night battlefield reconnaissance capability including armor plate, and self-sealing, extended-range fuel tanks. The equipments were built and demonstrated in Vietnam. Having demonstrated, in combat, real time target reconnaissance, including direction of artillery fire on targets spotted, the next problem was armament. A small drone helicopter cannot carry much weight and clearly can't carry a sophisticated weapon guidance system, although the helicopter can carry small guided weapons. We propose to continue the program for another year or so to achieve a successful transfer to the Services.

In fact the program had a rather checkered history as an experimental program in Vietnam and was never translated into an operational weapons system by the Services there or elsewhere. Conceptually, the program was something of a forerunner of later ARPA work on small remotely piloted vehicles (RPV's); that is, drone fixed wing aircraft that are envisioned for use in similar tactical reconnaissance and attack applications. In Dr. Lukasik's view, however, the drone helicopter project was somewhat akin to an extinct branch of an evolutionary tree which resembles a later development, but in fact was not a direct predecessor.

Of the other Vietnam-related developments in advanced sensors, there appears for the most part to be a similar record of no or limited success. There was, for example, considerable experimentation with mounting sensors on both free and tethered balloons. The latter research was continued in a non-Vietnam context and ultimately resulted in a modest program transfer to a Service (an ARPA-built tethered balloon is in use as a sensor platform at one U. S. site). Tethered balloon technology also resulted in a commercial spinoff, with a firm marketing the balloon as a TV-radio relay for use in developing countries. There was considerable research on battlefield night vision devices, initially performed with the Vietnam context in mind and continued on a modest scale in the 1970's as part of a broader program with Army participation. Likewise considerable effort was devoted to developing various "intrusion detection" devices for Vietnam, an example being the "Camp Sentinel" radar developed by Lincoln Laboratories and given limited operational exposure in Vietnam.

A common problem with much of the Vietnam-related developments in Advanced Sensor, as with AGILE's Vietnam-oriented hardware projects, appears to have been the difficulty in rapidly transforming new experimental devices into reliable operational equipment that could win the acceptance of U. S. or South Vietnamese forces and then be produced and delivered in sufficient quantity to achieve a significant impact. The rapidly changing character of the war continually posed obstacles to this process and Congressional disillusionment and the shift of policy toward Vietnamization further undercut any potential contribution through advanced R&D. Though many aspects of the program remain obscure, there seems to be considerable agreement among ARPA personnel familiar with it that no truly major Vietnam successes emerged.

Rechtin recalls that ARPA had a couple of good people and "could put on programs," but he did not see the justification for creating a large new office and suspected that the "critical mass" in terms of size and ideas was missing in what he had:[100]

> [It] was, to me, something like playing a card game where you just have cards. You're not quite sure how you are going to use them. But that's what you had been dealt and you can do interesting things with them. You can pick up problems that need to be picked up. [But] we had more money than ideas at that stage.

At best, ARPA could rationalize that the technologies in and of themselves may have been worth pursuing. But that is a lame justification for a program at the $30 million level. In essence, under intense Vietnam War pressure, ARPA weighed in at Foster's urging with what was undoubtedly a tremendous waste of money in the attempt to force feed "solutions" to the problem. Unfortunately R&D and technology could no more provide the "equalizer" for the U. S. vis-a-vis the North Vietnamese and Viet Cong than it did for the indigenous forces. Rechtin also recalls that ARPA got into more acrimonious roles and missions and managmeent controversies with the Services over the advanced sensors work than for any other program, including AGILE.[101] Herzfeld has a similar recollection.[102]

> As U. S. combat forces became involved in Vietnam ... the Advanced Sensors project, mostly because of the interest of the then-Director ... and of Foster, became a very sophisticated, quick-reaction capability to help U. S. efforts in Vietnam, both combat and intelligence.... [E]ventually we got into roles and missions arguments because it looked like the two [ARPA and the Services] were doing the same thing. They occasionally were very close. Sometimes exactly the same.

Advanced Engineering

Advanced Engineering was the only completely new program office established during Dr. Rechtin's tenure. The program was initiated with about $3 million in funding in FY 1969, was increased to about $13 million the following year, and continued at the $10-15 million level until folded into the Tactical Technology office. It was designed to focus on "selected tactical warfare problems of a multi-Service nature, particularly in areas involving mechanical, aeronautical, or hydrodynamic engineering."[103] It was clearly established at ARPA's initiative rather than as the result of any new priority assignment from the Secretary or DDR&E and the motive was influenced by the need to solve "the problem of what to do with a couple of guys we had." [104] Rechtin's ability to do so is a testment to the strength of his relationship with the DDR&E.

The mix of projects developed in Advanced Engineering was rather heterogeneous and it was used primarily to house hardware-oriented projects of a tactical nature which ARPA had gradually picked up, but which did not fit nicely into other office programs. Projects handled through this new office included development of techniques for quieting aircraft and helicopters for such missions as tactical reconnaissance; demonstration vehicles were developed and used experimentally in Vietnam and there has been significant technology transfer to Service programs. Another program involved R&D on small arms as part of a joint ARPA-Army program. ARPA supported a Small Arms Advisory Committee to review areas of improvement in small arms and undertook various specific projects, such as the development of a low-maintenance rifle and research on small rockets. A major effort went into surface effects vehicle (SEV) technology, conducted in cooperation with the Navy. The program later came to focus on development of prototype SEV's for operation in the arctic environment (which provided a boundary between ARPA and Navy efforts), and a related research program on the arctic environment was established. Another Rechtin initiative was research into the development of large ocean floating platforms "for a wide variety of military purposes including antisubmarine warfare, aerospace surveillance and defense, and as a forward logistics base in support of various tactical operations." [105] The program included prototype development on one "flippable barge" configuration that was expected to contribute to larger platform design.

The Advanced Engineering office was small and of relatively short duration and most of its major projects (notably SEV's and floating

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* Examples are the "jet belt" (or individual flight machine), the quiet aircraft programs initiated in AGILE, and the floating platform project initiated in STO.

platforms) are rather widely acknowledged to have been failures. The office is of particular interest, however, because it illustrates the kind of new initiatives in which ARPA tended to become involved in the late 1960's and because it presaged, to some extent, the character of ARPA programs and offices which were to develop in the Lukasik period. On the first point, the projects that ARPA tended to initiate in the late 1960's were often fairly discrete pieces of technology aiming toward a specific end-product rather than a broader technological attack on a major mission. That is, ARPA's new initiatives tended to be items like SEV's, floating platforms or a new type of small arm, in contrast to research and development in support of nuclear test detection, ballistic missile defense or counterinsurgency requirements. On the second point, but related to the first, Advanced Engineering was the first new ARPA office neither wedded closely to a specific mission problem (as were VELA, DEFENDER and AGILE) nor to a specific technology/discipline (as were Behavioral Sciences, Energy Conversion, Propellants, Information Processing, or Advanced Sensors). As initially conceived Advanced Engineering was thus the direct predecessor of the Tactical Technology Office, providing a home for widely diverse projects relating to "tactical" military problems. STO, of course, was conceptually the companion to Advanced Engineering (and, subsequently, the Tactical Technology Office), dealing with "strategic" concerns. However, STO initially was more focussed than Advanced Engineering because of its DEFENDER legacy.

Advanced Engineering was, in any case, the first totally new office created without a rather specific mission or disciplinary focus and it helped pave the way for ARPA's organizational structure in the 1970's. Then the two broadly-based offices, TTO and STO, dominate the budget and there is much greater emphasis on cross-office programs and on justifying the ARPA program in terms other than an office-by-office basis. The shift in this direction did not come easily and there was an attempt in the Rechtin-Lukasik transition period to define Advanced Engineering more narrowly by focussing it on marine, or Navy-related, concerns and by designating the Overseas Defense Research Office as land warfare or Army-related. The move toward more broadly oriented offices, however, was finally cemented as a consequence of the various difficulties encountered by Advanced Engineering, Advanced Sensors and Overseas Defense Research.

Materials Sciences

The Materials Sciences program went through a rather traumatic period during Dr. Rechtin's tenure, especially its largest component, the IDL's. Neither Foster nor Rechtin were strong proponents of a large basic research (6.1) element in ARPA. Both stressed exploratory development (6.2) activities. Beyond that and general problems with Congress concerning Defense support of basic university research, there were some particular points of irritation in the IDL program.

The first of the Rechtin-Foster difficulties was fundamental disagreement with the concept of institutional or "block" funding, whereby ARPA underwrote support of the materials laboratories without requiring any specific end products (other than a general annual report)* and without tying the support to performance on any specific projects. The laboratories were free to seek additional project-based support (and did) from the Services and other sources, but the continuation of ARPA funding was not linked to any particular IDL accomplishments. Beginning with the Herzfeld period, and much more aggressively during the Rechtin period, ARPA attempted to influence the direction of IDL research by acquainting IDL management with priority DOD materials problems and by using the ARPA-supported National Materials Research Council as a vehicle for highlighting materials research problems and recommending project areas. This influence, however, was rather indirect and based on persuasion rather than firm administrative guidance, and the IDL's had great flexibility in their use of ARPA funds. Dr. Rechtin regarded this as a clear case of "non-management" and a primary example of ARPA's overly academic posture:[106]

> When you looked into the IDL's, they weren't really being managed by ARPA at all. They had all this money and they were just going their own merry way. They were an anachronism in the late 1960's.

On top of that, Rechtin did a personal evaluation of the work done by the IDL's and concluded to his satisfaction that the return on all that money was questionable.

The second major grievance against the IDL program was the issue of forward-funding. When the IDL program was established, it will be recalled, ARPA not only committed itself to financing the building of laboratory facilities and providing an annual funding base, but also to providing three years of advance funding. The rationale for this technique was that universities needed to have assurances of future support in order to make long-term faculty commitments, establish curricula and student research programs, and so forth. Neither Foster nor Rechtin accepted this rationale, at least not to the extent of providing a guarantee of three full years of funding in advance. Rechtin, in fact, considered it a "gravy train" and a "rip-off" and a symptom of

* These annual reports were so lightly regarded that one university (Harvard) inadvertently submitted reports on another (non-ARPA supported) program for three years, to meet this requirement, without the error being detected.

university mistrust of the government:[107]

> By some fantastic decision somewhere the universities were given four years advance funding in the bank -- absolutely unbelievable.

He argued that the rationale for such guarantees to a university had no more justification than would similar guarantees to private industry, which also had problems of maintaining quality staffs, laying future corporate plans, etc. Rechtin felt that both universities and private industry had to accept some level of uncertainty in future federal research support, while demonstrating trust that the government would not be capricious in changing its research support patterns. He felt, in fact, that DOD in particular had been a very stable partner. The combination of university insistence on block funding (with project decisions made independently at the university) and long-term support impelled Rechtin to believe that the arguments were specious, reflecting pure self-interest and an unreasonable disdain for Defense needs.

Rechtin assumed that Congress did not know about the forward funding and other features of the IDL's and worried about what it might do if it did know, although ironically Congress supported them when the program was formulated in 1958-59 and even chastized ARPA for being too slow in getting it underway. Nonetheless this was a different Congress in different times. He was also disturbed about Congressional reaction to DOD sponsorship of anti-Vietnam War professors:[108]

> What with the Mansfield amendment and all, the Defense Department was not a safe home for those kinds of things anymore. And the guys in them [the IDL's] didn't have any real idea of Defense needs. They wanted to work on materials, Defense or no Defense. As a matter of fact the 'no Defense' was preferred ... and some of them stood up and said 'Yeah, we're getting money from Defense, but we're really not doing anything for them.' And that didn't help anything either. That gets right to the Congress through the local newspapers. [I said] look we've got to get those things over to the NSF and as fast possible.

Most important, the IDL's had become a symbol for everything thought to be wrong with ARPA, particularly loose management, profligate spending inadequate accountability, and university research favoritism. To Rechtin they were a red flag, an actual threat to the Agency's viability. The notion of a university requirement for guaranteed continued support elicited this reaction:[109]

> You're crazy in the head. So that's why I got rid of that one. That was bad financing. The worst. And what would have happened was that the Congress would have picked it up and said 'Geez, ARPA, if you've got that kind of money laying around, you've got much more than you need. And we stood a very good chance [of] having a great deal of ARPA's annual funding wiped out. And that's what I was fighting for. I had to keep ARPA alive, as I saw it.

Thus, whereas Rechtin defended AGILE and the behavioral sciences program in the face of Congressional attack and even argued for budgetary increases, the materials research budget was severely cut back through both decreased requests and reprogrammed funds were largely devoted to Vietnam-related expenditures. The Materials Sciences budget was approximately \$27 million in FY 1967, \$4 million in FY 1968, \$16 million in FY 1969 and \$15 million in FY 1970. The IDL reductions were at first described as a one-time reduction (reducing three years advance funding to two), and subsequently as a reduction to the "Themis"* mode which essentially provided one year advance funding spread over a two year period (first year at 2/3rds the current year, second at 1/3rd). Once the lower budget levels became set for the office, however, it became difficult to restore IDL funding to its traditional annual expenditure level of around \$18 million. IDL funding remained a problem until the program was eventually transferred to the NSF.

Aside from the cut-back in continuing institutional support to the IDL's, the remainder of the Materials Sciences program was also reoriented in line with Rechtin's emphasis on projects of demonstrable applicability to the Services and on project transfer and tangible products. As stated in his FY 1970 submission to the House Appropriations Committee:[110]

> The Materials Sciences Office is now concentrating on a further problem, that of reducing materials science to practice by demonstrating novel devices and new techniques. In contrast to the long term core funding of the interdisciplinary laboratories, the separate programs exploiting the basic science will be relatively

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* Project Themis grew out of an initiative by President Johnson to create centers of excellence in so-called "have-not" universities. ARPA played only a small part in the DOD-wide effort, which engendered considerable criticism in Congress. It was regarded by Sen. Fulbright and others as more of an aid-to-education measure than a legitimate DOD program.

> shorter term, on the order of three to four years each.

Project examples included armor research at Livermore Radiation Laboratories, research on the use of rare earths to reduce magnet size and weight in motors and generators, research on non-destructive testing of materials during the manufacturing process, and others.

Dr. Rechtin's interest in projects leading to devices and "exploiting the basic sciences" led, by the end of his tenure, to the initiation of a number of efforts which might be more properly characterized as 6.2 exploratory development projects than 6.1 research projects. Despite the fact that the office is listed as a 6.1 office in 1975, it has actually become a balanced 6.1-6.2 effort. This is also true of the Behavioral Sciences and Information Processing efforts. The impetus for all of these changes came during the Rechtin period. The net effect has been a considerable shift of the ARPA effort toward exploratory development activities, contrasted to the post-space, pre-Rechtin years.

The IDL's, rechristened Materials Research Laboratories (MRL's), remain the elite institutions in this field in the United States. They were referred to in the following terms recently in Science, along with acknowledgment of ARPA and its block funding approach:[111]

> This policy (inherited by the National Science Foundation from the Advanced Research Projects Agency) has created an elite in the materials community in that the MRL universities, tend to be able to more easily buy the best equipment, attract the best faculty and, in turn, the best research students, followed by a big advantage in attracting more funds, and so on.

Information Processing Techniques

In contrast to the Materials Sciences Office, ARPA's Information Processing Techniques (IPT) program never generated a hostile response from Dr. Foster, Dr. Rechtin or anyone else concerning its own rather broad institutional support role vis-a-vis a number of major university programs. Foster's FY 1969 House Appropriations presentation even highlighted this role as one of the primary accomplishments of ARPA and justified the program on its indirect impact on DOD:[112]

> ARPA continues to be the primary source, public or private, of support for the growth of computer science in universities. These university programs have provided trained

> computer scientists to both the Department of Defense and its contractors, and have developed a base of supporting research upon which much current computer technology rests. University computer science research contributed significantly to the development of interactive, multiple-access computer systems technology, which the Department of Defense is now using in several of its major computer installations.

Reflecting solid support for the program, its budget grew from about $15 to $25 million during Dr. Rechtin's tenure.

The excellent image of the basic research components of IPT compared to the Materials program is due to several factors. First, the IPT program did not tie up millions of dollars in three-year advance funding arrangements; although there was some advance funding in the IPT university programs, it was shorter duration and much less visible. Second, the urgency and importance of developments in computer technology appears to have been widely felt in the late 1960's, whereas materials needs no longer held the spotlight in the way they did in the late 1950's and early 1960's. Finally, the IDL program also suffered from too much success in the sense that concerns over a glut of graduate students in a number of materials fields were beginning to be felt by the late 1960's.

If IPT's basic research work enjoyed a better image within DOD than that of the materials program, this nevertheless did not hinder a shift in its emphasis during the Rechtin period to exploratory development. Much of the university work within IPT obviously had an exploratory development flavor anyway (notably development of the second-generation MULTICS time-sharing computer), but the expansion of the IPT budget was accounted for almost entirely by two exploratory development programs with major non-university participation. These were the ILLIAC IV computer development, initiated during the Herzfeld period, and the ARPA distributed computer network, generally called ARPANET. Dr. Rechtin's FY 1971 budget request created a new 6.2 program category called Distributed Information Systems just to cover these two programs and their annual funding for over $10 million.

ILLIAC IV and ARPANET came to dominate the IPT program throughout the Rechtin and Lukasik periods. Dr. Rechtin stuck with ILLIAC IV, in particular, despite numerous difficulties which could easily have resulted in program cancellation, e.g., student unrest directed at the program at the University of Illinois, a major cost over-run by the prime hardware contractor,* failure of a major sub-contractor to deliver a key component, and disappointment with the management performance of both contractors and the Service agent. He did so because he worried about the tendency of giant computers to fail because of inadequate software. Military computers were vulnerable to data saturation and he posited that U. S. defense, forswearing a first-strike posture, would be more critically dependent on information processing than would the Soviets. This logic attracted him to the potentials of parallel data processing and hence the ILLIAC experiment. ARPANET encountered less severe difficulties than ILLIAC, but required steady and substantial support for a long period prior to the demonstration of a substantial working system. Rechtin recalls that ARPANET's original objectives were more or less improved cost effectiveness, i.e., saving money on computing and information exchange. Ultimately it was to result in a significantly different conceptual approach to computing in general.

That both of these programs were supported with growing budgets and were strongly defended before Congress is a product of their congruence with the Foster/Rechtin conception of the ARPA role. Both resulted in tangible products incorporating advanced technology. Both were potentially transferrable programs which required only a finite period of ARPA funding rather than broad institutional support. Both had important cost-savings implications if they proved successful, an important criterion in an era of sharply constrained Defense budgets. Numerous potential applications of military relevance could credibly be presented for each program. In addition, computer technology was, to the layman, perhaps the primary example of important and practical advanced technology, and was not likely to be questioned as to its appropriateness to an advanced research projects agency. Hence the IPT program, and particularly ILLIAC IV and ARPANET, were particularly appealing to the DDR&E and ARPA's Director, and appropriate to the times in which they were undertaken.

The ILLIAC IV Controversy. During January, 1970, a bitter controversy broke out on the University of Illinois campus concerning the propriety of the University accepting DOD support for the ILLIAC IV computer. A discussion of this controversy is included here as an illustration of the sad state of DOD-university relations in the late 1960's and the problems posed for ARPA by these developments.

* The contractor estimated total machine costs at $21 million in January 1967; by December 1970, cost to completion was estimated at $27 million for a machine with only one-quarter of the processing elements originally planned. Final costs were considerably higher, due to extensive modifications and parts replacements (through various contractors). At one point in the contract an $8 million overrun condition surfaced virtually overnight.

ILLIAC IV was a highly visible program. Its funding had risen to a level of over $24 million by late 1969. Though a large portion of these funds merely passed through University of Illinois contract monitorship to hardware contractors, the large budget nevertheless made the effort the largest DOD contract in University of Illinois history. In addition, the project had been given considerable publicity as the "world's largest computer" and as a major departure in computer design. Plans provided for the installation of the large computer in a specially designed university facility in 1970.

Due to cost increases in the ILLIAC IV project, the Illinois Board of Higher Education scheduled a review of the program early in January 1970. This event appears to have interested the student newspaper, The Daily Illini, in the computer.[113] The first Daily Illini articles simply highlighted that ILLIAC IV was funded by the Department of Defense; that approximately two-thirds of the compter's time was to be devoted to Defense projects and that a major application was planned to be BMD simulation; that there were major cost increases in the project; and that a number of non-military uses were also planned. Though the Daily Illini was soon to take an editorial position against military sponsorship of ILLIAC IV, the first articles appeared objective in tone and generally accurate.

Despite the rather straightforward presentation in the first student newspaper articles, a strong anti-military reaction was obviously expected by the project's staff. An attempt was therefore made to assert that the staff was non-military in orientation and that the non-military applications were by far the most important. Dr. Slotnick, head of the project, was quoted in the first article as saying:[114]

> I know the military side of the Department of Defense (DOD). Some of them are dangerous fools. But their power base is not dependent on me. If I could have gotten $30 million from the Red Cross I would not have messed with the DOD. But you have to measure the thrust of what the nation does with the DOD versus what you're consciously working to achieve. These military things are not my interests but Department of Defense interests. They are interested in ways of meeting their objectives while at the same time they are offering me a way to meet my objectives ... work going on in this campus now is not defense-directed. People all over the country may be working on military things for ILLIAC now, but we aren't and so that's not what gets talked about here.

Slotnick went on to say that the military relevance requirements of the new Mansfield Amendment could probably be satisfied by "technological fallout" of the project, again emphasizing the basic non-military thrust of the work. He also indicated that the University was seeking other non-military sponsors. In a second Daily Illini article Slotnick is quoted as saying that when the "minuses represented by the Defense Department's role in the project" are compared to non-military advances, the results are positive; he also criticizes the first article for not adequately stressing non-military applications such as calculations relating to ecology and agricultural planning.[115] The third Daily Illini article was then devoted to these non-defense applications. In summary, the initial project team response to student publicity was essentially to disavow the project's Defense Department sponsorship except as a necessary evil. This naturally rankled within ARPA and DOD and a DOD spokesman is quoted as calling Slotnick a "volatile visionary" in reaction to his comments.[116]

The attempt to disassociate ILLIAC IV from the military was unsuccessful, and subsequent articles, letters to the editor and editorials in the student newspaper grew increasingly hostile. To quote from a random selection:

> ... [I]f the ILLIAC IV aids in the creation of such [nuclear] weapons systems, or if it helps develop counterinsurgency programs, there is almost nothing it could do to counterbalance such activity.[117]
>
> As additional aspects of the ILLIAC IV are revealed, it becomes more and more evident that for nearly five years the University has intentionally masked from public view the Defense Department's role in the construction and utilization of the computer. It also appears that it was naive to presume that the men planning ILLIAC IV might have been acting with good intentions. It now seems more likely that there were no good intentions whatsoever for establishing the computer on this campus and allocating two-thirds of its time to the Defense Department.... Both the original and revised versions of the Slotnick and Alpert proposal for the center are blatant insults to the committee's intelligence and self-respect. The proposals are, in fact, an attempt to deceive not only the members of the committee but the entire University community as well. The original proposal is unbelievably short on rationale and supportive evidence. It also deliberately avoids any reference to the Defense Department and the military research that will consume two-thirds of

> the computer's time.... Slotnick's role in hiding the computer's military applications now argues against the image he would like to have projected -- one of a benign scientist committed to the problems of ecology and economic planning, but forced to accept money from the military to do it.[118]
>
> We realize that Slotnick fears the horrors ILLIAC IV may loose on the world through hands of the military leaders of this nation. We also are led to believe, from his statements to us, that he does not want to see those horrors happen, that his primary interest is in the "good things" the computer can do: planning for greater agricultural productivity, studying ecological problems, forecasting weather ad infinitum. ... But that Slotnick may have good intentions is at best a mitigating factor and not a deciding one, and perhaps it is irrelevant.... And in a very practical sense, we also know that the 2/3-1/3 use of the computer is very misleading, too. We fear the military will get far more than two-thirds of the advantage of the computer, for it has far more resources to begin with -- and once it uses the computer to develop more ways to kill people and spend the people's money, it has far more influence to allow it to bring those effects of the computer into reality.... And considering the evil demonstrated by our military in recent years, we can only decide we would rather have seen the University resistant to the evil -- perhaps ineffectually, though perhaps not -- than complicit with it.[119]

By February 1970 the temper of the Illinois campus debate was extraordinarily bitter. Slotnick's reply to Daily Illini editorials charging deceit are illustrative:[120]

> More recently the comical aspect of these attacks have dissipated to reveal the ugly tactics that those of my generation remember so well in Nazi Germany. Unnamed professors act as sources of information but are not identified lest the accuser be exposed to cross-examination. Vicious slander and character assassination have substituted for reasoned arguments.
>
> The repetition of words such as "deceit" and "lies" do not make the arguments valid. They do make them more painful. Vitriolic personal attacks in unsigned editorials impugn my motives.
>
> I find myself on trial in the campus newspaper which graciously acts as judge, jury, defense and prosecuting attorneys. Apparently my sole role in

the Kafka-like trial is to submit to assassination or perhaps like Herr K. to relieve them of the responsibility and do it to myself.

The ugly controversy continued for weeks with radical campus groups urging rejection of the computer installation, at least as long as Defense sponsorship was involved. A teach-in was conducted against ILLIAC IV and one protest resulted in a small number of arrests. Nonetheless, the University administration did approve continuing support for the ILLIAC IV installation and the establishment of a computation center to direct the program. After this defeat for the opponents of the project the controversy gradually died down. In the aftermath of the University of Illinois confrontation, however, there was a redirection of the ILLIAC IV program, and ARPA soon began to consider an alternative to locating the computer at Illinois.

Within the year it was decided to open proposals for location and management of the computer installation to competitive bid. Six organizations, including Illinois, submitted proposals, and by the end of the year the proposals were evaluated and the computer installation was awarded to NASA-Ames in California. Responding to a Congressional query in early 1971, Acting Director Lukasik denied there was any connection between this decision and events on the Illinois campus, stating that the NASA-Ames proposal was the low-cost proposal and was unanimously rated as a technically superior management proposal by the review committee.[121] Indeed, there was prior dissatisfaction with the management of the ILLIAC IV program under the University of Illinois arrangement, and the shift to NASA-Ames occurred along with a number of other program changes, including the elimination of the Rome Air Development Center as contract agent. The University of Illinois continued to receive ARPA funding relating to the project and remote access to the computer was developed through the ARPANET system; however, funding was reduced and made much less visible without the hardware installation.

Despite the denials and the existence of other reasons to change plans in locating the ILLIAC computer, it is clear that the campus conflict left an extremely bad taste in ARPA's mouth, particularly the response of the campus project management to student criticism. The Illinois project was not the only university effort which encountered such criticism (behavioral science projects were a major problem area) nor was it the only one in which the response of ARPA-supported university contractors was found wanting. The reduction of ARPA university-oriented programs throughout the Rechtin-Lukasik period was clearly influenced by such episodes whether or not there were other sound reasons. As Rechtin said of some of the IDL schools: when "some of them stood up and said "Yeah, we're getting money from Defense, but we're not really doing anything for them'... that didn't help anything...."[122] He linked the Illinois group with this attitude, adding that they "folded" under pressure. Dr. Lukasik, after mentioning the Illinois and other incidents, noted being personally "hurt" by the way such matters were handled:[123]

> Curiously enough it is only in the Defense Department that you can get the freedom to do a lot of very important science ... I could understand the feelings that the Vietnam War engendered in people. I fully recognized the vividness of the war. And yet I was always disappointed that people couldn't understand.... 'I know you don't like the Defense Department. I know there are a lot of bad guys in that sense, but... don't lose your sense of perspective, this is ARPA and you know what we are doing and you know the way we play it....'

In short, university remarks that Defense money was used only because it was the only source, that the Pentagon was full of "dangerous fools," and so forth, cut very deeply within an ARPA which had prided itself for years on its ability to work productively with university researchers, with rarely even a trace of accusation that 'pressure' of any kind was applied to their professional work. ARPA was wounded too by the silence of so many academicians who knew that to be a fact, but found it convenient to remain mute. The changed character of ARPA-university relations in the 1970's carries forward a significant legacy from the ILLIAC IV incident and similar events.

Behavioral Sciences

Perhaps the most interesting facet of ARPA's behavioral science research program during the Rechtin years is that any program survived at all. Defense-sponsored behavioral science research was under vigorous attack by Congress, led by Senator Fulbright, throughout much of the period, as was Defense supported university-based research in general. As noted above, Rechtin was quite disenchanted with university reactions to the war and campus unrest directed against the Defense Department and ARPA. Forward funding arrangements which had created irritations with the IDL program also existed in some of the behavioral sciences university programs, although some of them included the controversial building construction "use charge" provision. Nevertheless, the behavioral sciences program survived the period with a budget roughly equivalent to that in FY 1967 -- around $5 million -- after enduring one major cutback to reduce forward funding (a dip to $1.1 million in FY 1968). In contrast, the materials program never returned to its pre-1968 funding levels even after the resolution of the forward funding issue.

The ARPA behavioral sciences program was a major part of the DOD's broader program containing five major components, three noncontroversial and two highly suspect to Congress. The three acceptable components included human performance, manpower selection and training, and human factors engineering. The unacceptable components were: (1) a program called "cultural and social factors" in the FY 1969 budget, which covered studies relevant to "training for overseas assignments, counter-insurgency, psychological operations, military assistance, and basic data inputs to policy planning," or those involving "basic military, economic, and political factors bearing on possible U. S. military activity,"[124] and (2) "policy planning studies," described as "strategic planning in response to changing patterns of political and power alignments; threat analysis; contingency planning; force structure; and R&D requirements."[125]

In 1968 Drs. Foster and Rechtin were prepared to defend these controversial aspects of behavioral science research and did so largely on the grounds that such research was relevant and important to the resolution of the conflict in Vietnam. Dr. Foster, for example, argued before the Senate Foreign Relations Committee in May 1968, that the Southeast Asia experience reinforced the proposition that all aspects of a country's life are related to military action in a counterinsurgency situation, and hence are appropriate for DOD research, although the DOD's research requirements are not always unique to it and the responsibility might be shared with the State Department and other agencies. The DOD's efforts, he implied, stood out only because other agencies had defaulted on their responsibilities:[126]

> ... the DOD must carry a larger R&D effort because our responsibilities are great and the national effort in internationally oriented social and behavioral sciences is, in our opinion, still too small.

This rather courageous defense of the DOD's role did not satisfy Senator Fulbright who replied that, in his opinion, the DOD's responsibility "was to prosecute war or to provide military forces capable of defending an external attack." Fulbright added that he did not believe "the President would expect you to advise him on the psychological, cultural and ideological background of a country."[127]

By mid-1969 Foster had recognized that the opposition to foreign area-oriented social science research was so great that a reduction of effort was necessary. He announced that such efforts would not be expanded and that he would transfer "a few projects of multi-agency interest" to State, NSC or other non-Defense agencies.[128] Despite this promise, Senator Fulbright introduced an amendment in August 1969 calling for a reduction of foreign area and policy planning studies. Overcoming opposition from Senators who felt this would prevent an orderly transfer of meritorious projects, the amendment passed 49 to 44.

The 1968 debate, however, had provided ample warning and the controversial programs had already been eliminated from the ARPA behavioral sciences budget prior to the Senate vote. In the spring of 1969 Dr. Rechtin announced "a major technical reorientation... terminating almost all ARPA Behavioral Sciences Research work outside the U. S."[129] U. S.-based research pertaining to foreign cultures was to be deemphasized. Thus the initial defense of behavioral sciences in terms of broad Southeast Asia requirements was abandoned and the directly related research terminated. Nonetheless Dr. Rechtin requested an increase in the behavioral sciences program budget from $5.2 million in FY 1969 to $5.36 million in FY 1970.

In order to save the behavioral sciences program, Rechtin narrowed its main focus and associated it more closely with the relatively noncontroversial and growing information processing research effort:[130]

> ARPA has reoriented its Behavioral Science research work into a direction where there is broad agreement in the research and defense community that more promise exists -- the interdisciplinary combination of the computer and behavioral sciences in specific problem areas. The objective is to produce results for Defense user organizations within 5 years.

According to participant accounts, the decision to move in this direction was a close one and the unofficial word had gone out that in view of Congressional problems, program elimination was being seriously considered because: "it was just too much trouble."[131]

What appears to have ultimately determined the continued existence and thrust of the program was that the office was between directors, temporarily headed by the IPT director, who (along with then-Deputy ARPA Director Lukasik) had an interest in salvaging something. What was continued was thus rather naturally heavily colored by computer science interests, since the overall program and the major new initiatives (notably the Cambridge Project to design computer-aided data management and analysis systems for the social sciences and the Center for Computer-Based Behavioral Studies to work with computer gaming techniques) were essentially shaped by a computer scientist.

According to Dr. Rechtin, the Cambridge Project (known as CAM) represented one of the few times that he actively collaborated to create and sustain a university-centered basic research program.[132] He did so in part because Dr. Wiesner, by then President of MIT, felt it was important to demonstrate that DOD and a university could cooperate on a purely professional basis. The purpose of the program was (1) to develop computer methods and programs that were needed in behavioral science and its applications, and (2) to combine these programs into an integrated computing system. The Cambridge Project programs and system eventually were of some use to elements of DOD in handling such problems as logistics and inventory control, as well as some problems somewhat more closely related to what a layman might consider behavioral science. The project, in fact, represented a highly competent attack on developing computer techniques for large data base, multi-variable problems, which frequently arise in the soft sciences but are applicable to a wide variety of disciplines and fields: It did not, however, result in large-scale dramatic breakthroughs for behavioral scientists, and certainly did not revolutionize the field in the manner envisioned by some of its early proponents, partially because of institutional problems in introducing individual social science researchers to a technically complex computer methodology for which they often had little relevant background training or experience.[133] There appears to be little disagreement with the proposition that CAM was a significant technical success, but the scope of its impact has thus far been more limited than originally anticipated. CAM, like ILLIAC, became a source of considerable campus controversy for a time, but was more ably defended by its proponents, and substantial work related to the original project continues on the MIT campus in 1975.

The new behavioral sciences program reflected Dr. Rechtin's interest in program transfer, as a five year target was set to establish applications. In addition, though the program was still nearly completely university-based, Dr. Rechtin's general resistence to heavy reliance on the universities was reflected in the program description:[134]

> Initially, we have extended support to three basic programs to be conducted at universities where unique talent now exists. Simultaneously, we began a management inquiry to determine how to use an applied research organization to apply the results of the basic research to specific and immediate DOD operational problems. As work progresses, and to the extent that the results of our management analysis warrant, we plan to phase down ARPA sponsorship of university participation in the three programs.

In summary, therefore, the behavorial sciences office seems to have survived in the late 1960's largely through luck and a major change in program emphasis. The most controversial aspects of the old program, foreign area and cross-cultural research, did not survive. By 1970 the program could almost have been considered a logical component of ARPA's information processing research program, and merger of the two offices was indeed considered. It did, however, contain some elements which were not directly related to computer technology and these helped retain program distinctions into the Lukasik period, when the program was given the less controversial title of Human Resources Research and the effort was expanded.

POSTSCRIPT ON THE RECHTIN ERA

Given the traumatic environment of the late 1960's in ARPA, it is valuable to survey the situation following the Foster/Rechtin survival operation, with emphasis on Rechtin's summation of what took place. Clearly, ARPA had survived, with annual budgets sliding toward $200 million. Perhaps equally as important, Rechtin had established a strong bond of rapport with the DDR&E. Rechtin found Foster serving as de facto Director of ARPA when he arrived. In six months that problem was solved:[135]

> [W]ithwin six months he forgot about ARPA; he had nothing to worry about anymore. It was flying right and doing good things which could be justified.

It got to the point that Rechtin felt he had re-established some independence for the Agency:[136]

> Johnny Foster was so happy to have ARPA tightly managed that he virtually let me do anything I wanted to. I had a review about once a year.... He would sort of poke at things a little bit. But he backed off from the sort of day-to-day attempt to manage the place.

Sounding more and more like Sproull, or Herzfeld, Rechtin also believed that he had restored some balance to the staff level ARPA-ODDR&E relationship:[137]

> I maintained a sort of an arms length relationship between ARPA and what it was doing, and the DDR&E offices. I didn't want to see it where those offices were attempting to control the ARPA projects, because I felt their job was to make sure of what was going on in the Services which was one hell of a lot bigger. They should be looking at that balance. We should be looking at the more advanced ideas, that nobody was quite sure about or the more controversial or whatever. If you start to get to where the guys in DDR&E could use ARPA as a slush fund for doing things they wished they could control directly instead of indirectly through the Services

> [you are in trouble]. I wasn't going to help much, because I was pretty hard nosed about that part of the game. I wasn't going to have them, particularly the guys under them, go over and try to tell the ARPA guys what to do.... They probably were irritated because they didn't have free money, probably wished they were in ARPA and a lot of them attempted to transfer to ARPA where they would have direct money, but that wasn't their job.

Nevertheless, ARPA offered more direct dollar support to ODDR&E in the early Rechtin years than in any other period. The tap was open for Vietnam reprogramming and Rechtin made available to each Deputy DDR&E a substantial "budget" allowance, up to roughly $2 million each annually, for use as they saw fit. Fortunately for ARPA's program stability, the DDR&E deputies were normally too busy to fully exploit such offerings and as the Laird/Packard reorientation began to change the ODDR&E role and Vietnam pressures declined, ARPA gradually became less subject to major budgetary "raids."

Rechtin was especially proud of achieving improved relations with the Services. He felt that they eventually stopped chipping at ARPA and saw the Agency more as an interested helper than a threat. The "low profile" method of operation seemed to help the Service relationship (especially ARPA's gradual entry into the Navy's undersea warfare preserve), although the approach runs the risk of making it more difficult to justify ARPA and its programs before Congress.

While the transfer mission was well-launched, strong program replacement ideas were harder to come by. As noted, higher authority no longer made major assignments to ARPA. Most of what emerged in Rechtin's tenure were generated internally, acknowledging the fact that ARPA has always served as a reflector and integrater of ideas in the scientific and technological community at large to some extent. Events were to show that few of the new initiatives taken then were successful and it was very questionable that they met the criteria of either threat of technological surprise or a potentially revolutionary breakthrough, e.g., the multi-million programs in Alaskan surface effect vehicles and ocean platforms. The Navy was relatively cool to these ideas, although the Navy's Assistant Secretary for Research and Development (former ARPA Deputy Director, Dr. R. Frosch) was personally rather positive about them. He argues that they were undertaken on a "laboratory scale" program budget rather than an "ARPA-scale" budget (like DEFENDER or VELA) and hence were not likely to show major results.[138] This leaves open the question, of course, of whether an Arctic Surface effects vehicle and the threat it is addressed to (never articulated), even if successful, warrants DEFENDER-class funding.

In retrospect an interesting feature of the Rechtin period is that individual programs proved to be far more vulnerable than the agency as a whole. While ARPA survived the period with a more than $200 million budget, there were numerous false starts that quickly fell by the wayside in addition to the shedding of many older committments. The insistence on achieving large scale program transfer contributed greatly to this turnover, but much of the turmoil simply resulted from "cutting losses" on efforts which proved unproductive, ill-conceived or unsaleable. That is, much of the program turnover was due to work efforts turning sour for any of a number of reasons, followed by ARPA scrambles to curtail efforts and make adjustments. ARPA often did not, in other words, insist on transfer for cosmetic reasons: many programs either were killed or withered and died, and deserved that fate.

The above situation symbolizes the great problems of this period, but it also serves to highlight an ARPA strength. The typical ARPA program, be it an older inherited effort or a new Rechtin-era initiative, was not buttressed by an semi-independent bureaucratic structure aside from that which ARPA created for its own purposes, largely on an ad hoc basis. For example, there rarely were committees, peer-group review panels, large in-house laboratories, or large subordinate divisions that had sufficient standing to be able to defend a given program in the face of ARPA decisions that transfer or cancellation was either technically desirable or politically necessary. The lack of formal or informal program-oriented structures also meant that program difficulties became apparent to Agency management rather directly and with relatively little "papering over," aside from whatever defense might be provided by a sympathetic office director or program manager. As one contemporary office director stated:[139]

> One of the things which makes ARPA successful, where the NSF is not, is in the fact that it doesn't use that kind of committee decision-making structure. And therefore responsibility is easier to identify and corrective action is easier to take when things go wrong.... I wouldn't argue that ARPA under its modus operandi is any more likely to do things right than the National Science Foundation. But that's not the point. I think the point is when they do things wrong it's more obvious and it's more easily corrected.

Summing up the ARPA role and the reasons for it in testimony on the FY 1971 budget, Rechtin* emphasized the "high-risk," "revolutionary"

* This was the first verbal testimony from an ARPA Director in over two years. Dr. Foster handled the ARPA testimony in lieu of Rechtin in FY 1968 (Rechtin was new to the job, and Foster perhaps wished to demonstrate control over the ARPA program) and both Foster and Rechtin were requested only to submit written testimony for FY 1969.

research function and the traditional roles of filling Service "gaps" and serving as a neutral non-Service source of objective research:[140]

> The establishment of ARPA was a recognition of the fact that a Department of Defense R&D program based only on assigned roles and missions of the services could lead to serious interservice or tri-service gaps in our overall defense technology, particularly in an era of rapid technological change. The launch of Sputnik I by the Soviet Union is a dramatic example of one which played a leading role in the decision to establish ARPA....
>
> Since ARPA has no operational objectives or missions, it is in a position to take an unbiased approach to such problems as offense/defense balance in strategic weapons and the evasion/detection balance in nuclear weapons testing. The measure of success for ARPA is how well it develops and, subsequently, transfer technology to the services.

Amplifying on this discussion, Dr. Rechtin describes ARPA's "anti-surprise," multi-service R&D role as essentially a residual function, an unusually modest explanation of the ARPA function for an ARPA Director to make:[141]

> ... I see it [ARPA] continuing essentially the same role of looking ahead against the surprises of the Sputnik type in areas which are difficult for the services to cover, either because they are multi-service in nature or inter-service in nature or because the roles and missions haven't been defined for a new kind of technology.
>
> The existence of ARPA depends critically upon our basic rationale for how to do R&D. We believe that R&D should be done in the services because that is where the problems exist and that is where the best R&D responses to the problems can be made. However, it turns out that although this works for perhaps 97 per cent of the RDT&E budget, having the research and development and test and engineering in the services, there is about 3 per cent for which it doesn't complete the picture, and that 3 per cent is ARPA. ARPA's fraction of the total RDT&E is about 3 per cent.
>
> To manage the 3 per cent properly, you have to use it with considerable imagination and, obviously, avoidance of duplication, very close coordination with the

> services to find out what is going on, and what perhaps is being missed. Now, if it looks as though some things are being missed there are a variety of solutions.

To fulfill this residual role, ARPA is described as adhering to two primary principles:[142]

> There are two criteria for ARPA's success. The one criterion is that the work must be professionally done. If it is not professionally done we, as professionals, should be held accountable. The second criterion is that it must be successfully transferred to the services. If it isn't transferred to the services it will never reach operations and never affect the course of a war, and therefore it should not have been begun. These two criteria for success control ARPA and how it is managed.

Dr. Rechtin went on, however, to illustrate ARPA's multi-Service role with an example from the reentry physics field, an activity conducted by ARPA for over ten years and clearly not an example of a rapidly transferred program; nor are the operational systems impacts of the data it produces easy to trace in a clear, direct "transfer" sense:

> ... Let me give you an example of the kind of work which is difficult for a single service to do, but which, if you have a tie-across mechanism, it is better. A good example is reentry physics. Reentry physics tells the engineer what the characteristics are of reentry bodies as they come into the atmosphere. There are many services that are interested in that problem, but each for different reasons. They would tackle the problem in quite different ways if handled individually. By consolidating the interest and the research in that area we have indeed saved a considerable amount of money.
>
> For example, the Air Force is interested in reentry physics because of the design of its decoys. The Navy is interested in it for that kind of a reason, but the Army is interested in it for the opposite reason, trying to find out how one can discriminate against those decoys. So the Army would design a program to try to find the weaknesses in reentry vehicles and the Air Force would try to design a program to find the strengths in the reentry vehicles, and both of them care clearly based on the same physics. It is therefore, simpler for all concerned, and the services

> would agree, that to have one agency with no particular operational point of view in mind looking into that problem in the interests of all concerned is better. To make sure that everyone understands what is going on, we have a reentry physics steering group consisting of all of the services, plus the technical experts, plus the Office of Defense Research and Engineering. The same work would get done, but in this way the same work produces many outputs to many services.

Another aspect of ARPA's role was highlighted in the course of Committee questioning:[143]

> Mr. Davis. It might be termed a premilitary research organization within the Defense Department? Does that come pretty close to describing your activity?
>
> Dr. Rechtin. If I could change the word "military" to "Requirements," with a capital "R," the answer would be yes, sir. By this I mean that the military services, in order to do their work, must have a very formal requirement based upon very specified needs, and usually upon technologies that are understood. The difficulty is that it is hard to write formal requirements if you do not have the technology with which to solve them, but you cannot do the technology unless you have the requirements.
>
> There is a kind of chicken-and-egg problem in other words, in requirements and technology.
>
> ARPA is a way in initiating a startup when it is judged to be important. In that sense, it is premilitary or preformal requirements.

This rationale is vintage Roy Johnson, who used almost exactly the same words in trying to explain why ARPA existed in April 1958. Rechtin has further developed the nature of such a pre-requirement mission:[144]

> [I]t was right for Defense to invest money to break the old chicken and the egg problem: that you can't do research before you have an application, but you can't say what the application is until the research has told you what you can do. And ARPA, I thought, was a very good solution to the problem, allowing people to spend money <u>before</u> there was an obvious application. All you had to was say there probably are defense applications, not that there was a specific one. That was a way

> of breaking the cycle and allowing technology to get developed to a point where you could see how it might be used. I thought it was a very good idea. Very few countries are able to afford it, you have to spend quite a lot of money to be able to do it....

This is an explanation of ARPA that could readily have come from Johnson, Betts, Ruina, Sproull, or Herzfeld, but it certainly stretches both the "relevance" and the "transfer" criteria.

Finally, in response to a question concerning how ARPA projects are established, Rechtin cites the rationale that ARPA simply carries out tasks assigned by DDR&E:[145]

> ... The Director of Defense Research and Engineering determines that question on all major project assignments. We report directly to him and do no work unless directed by him.

To summarize this testimony, the ARPA role is thus described as undertaking the small percentage of R&D which cannot be handled through traditional Service arrangements, because the work is multi-Service or prerequirements in nature. In addition to this justification, however, the work must be recognized as important by DDR&E relevant to a military purpose assigned to ARPA. The criterion of "importance" is derived from either the threat of technological surprise or from the potential "revolutionary" impact of program results. Despite the prerequirements character of the work, transfer must be built into the program to assure that impact is obtained. Thus, the Rechtin definition of the ARPA role brings in almost all of the elements cited by earlier Directors, in addition to his own.

The difficulty with this multi-faceted definition lies, of course, in determining whether each of the several elements are mutually supportive. If research is truly "prerequirements" in nature, planning for early transfer has to be much more difficult. Similarly, using transfer as a primary criterion for success can inhibit willingness to undertake "high risk" research where payoff is by definition much less certain. If the DDR&E wishes ARPA to undertake an important multi-Service research problem, it is likewise not clear that such problems naturally tend to entail "revolutionary" implications. And Defense-relevant work may be entirely routine, sharing none of the other ARPA project attributes. Hence the question of the weights and priorities given to the various elements of the ARPA role and how to resolve them is left quite open as the Rechtin period draws to a close.

The entire spectrum of issues faced by ARPA in the late 1960's was also influenced by a very general development, the force of which should not be underestimated. This was the growing disenchantment with the potential of advanced science and technology to solve problems. This struck at the core of the ARPA rationale. In the Vietnam context technology was not showing that it could "win the war." In the strategic context, systems based on high technology led to incredibly expensive commitments with little if any, net gain to be seen in national security. The image of technology driving the arms race became credible even to supporters of strong Defense programs and large budgets, especially when men like York and Ruina and others began to argue that even defensive systems were destabilizing rather than benign elements in the national security equation. In addition, to many there seemed to be a dearth of new technological "breakthroughs," with nothing like the ballistic missiles or satellites of an earlier age on the horizon that might dramatically change the strategic balance. Even from his position as an advocate of advanced technology development, Dr. Rechtin found the late 1960's "idea poor" and meaningful new initiatives difficult to uncover.

RECHTIN'S DEPARTURE

In February 1970, Dr. Rechtin assumed the position of Acting Principal Deputy of DDR&E, while retaining his position as ARPA Director. In December 1970, he resigned the ARPA post to assume the ODDR&E position full time, and later moved to the position of Assistant Secretary of Defense for Telecommunications.

Given all of the factors at work in Dr. Rechtin's period, what is most surprising is not that ARPA failed to achieve all of its ambitious objectives, but that it managed to stay alive with a resource base strong enough to support its future. The move to Acting Principal Deputy DDR&E had the unfortunate side-effect of leaving ARPA with a part-time Director (referred to by ARPA staff members as the period of the "absentee landlord") at a time of considerable Agency drift:[146]

> [W]hen I was also Principal Deputy to DDR&E and also Director of ARPA, that was a very rough time on me.... For all practical purposes Steve [Lukasik] began to run ARPA. He did a good job of that in a very frustrating environment. Because he had to do everything in my name, and that's hard to do.

Morale plummeted as the Agency's staff felt even more vulnerable and neglected. During this period, ARPA was moved from its prime space offices in the Pentagon to an office building in the Rosslyn complex in Arlington, Virginia,* a move which was widely interpreted to re-

* Part of DEFENDER had been moved from the Pentagon much earlier, in 1967.

present the epitome of the Agency's downgrading. The following exchange with a thoughtful observer of the period illustrates the atmosphere that prevailed:[147]

A: [M]orale during the period of the absentee owner ... was very bad. But the one thing worse then the bad director is no director.
Q: The staff felt let down?
A: The staff just didn't know what was going to happen next. They didn't know who was boss. They didn't know who to follow. They didn't know whether anyone cared. In fact, I would argue that rather than the 1967 ... ARPA period, the possibly worse period was that 1970 period when they weren't even sure whether anyone cared enough about ARPA to bother appointing a Director. You know, that's even worse. At least if you kill something you know, you line it up against the wall, you take aim, you spend five minutes at the job and you kill it right. But to just let it wither away by not even allowing it to have a Director is almost the [worse].
Q: Psychologically, was the move out of the Pentagon a wrench for ARPA?
A: Yep ... [y]ou see the move, the decision to move, was made by Eb when he was up the hall [in ODDR&E]. The feeling was: he doesn't care anymore; he's not really coming back anyway, and so he could care less; he is selling us down the river...; we've become the pawn, and we are moving away from the center; ... and terrible feelings that this is the end.

Rechtin did not view the move in such apocolyptic terms (and his successor concluded that it was extremely beneficial to ARPA). And Rechtin's personal views of the ARPA staff, however, unsuccessful he may have been in communicating them, were overwhelmingly positive:[148]

> The [the ARPA staff] were exceptional when I got there and stayed exceptional while I was there. And from what I've seen of recent reviews, they are still very, very good. The government is just damned lucky to have the kinds of people that go to ARPA. I felt it when I first saw them. It was amazing. I was used to JPL, Lincoln Labs, AIA and other top flight outfits. OK, they were good. And I felt that, for the job being done, the guys in ARPA were better than any of them. Just <u>very</u>, <u>very</u> good.

Regardless of the ambiguities in ARPA's creation, Dr. Rechtin's departure from ARPA was gradual, not a sudden departure precipitated by particular dramatic events. His Deputy Director, Dr. S. J. Lukasik, slowly took over the functions of the Director and was eventually appointed Acting Director and then permanent Director of the Agency. He had been a member of the ARPA staff since 1966 and followed Herzfeld as the second Director to "rise from the ranks."

Dr. Rechtin left ARPA still intact and with an annual budget only modestly below that on his arrival, despite transfer of the core of the $125 million DEFENDER program and numerous other changes. He also left the Agency with a new emphasis on rapid project transfer, which had a lasting impact on the ARPA management approach; with decreased emphasis on longer range basic research programs; with a reasonably secure niche in the DDR&E family; and with closer connections to immediate Service concerns. At the same time Rechtin left an ARPA with an uncertain future.

CHAPTER VIII: FOOTNOTES

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Chapter IX

SURVIVAL AND ACCEPTANCE

THE LUKASIK YEARS: 1971-1974

The Setting - 1970

Dr. Stephen J. Lukasik was appointed Director of ARPA in January 1971 and was to serve in that post until January 1975. His tenure is the longest of the ARPA Directors -- counting his service as de facto Director during 1970 while Dr. Rechtin was doubling as a Deputy Director of Defense Research and Engineering, Lukasik was on the job for five years. There had been no outside search for a new Director. To Rechtin and Foster, Lukasik was the obvious candidate to carry on the reshaping of ARPA that the DDR&E wanted.

Vietnam remained very much a part of the ARPA setting, but by 1970 Nixon Administration policy had become well established. The gradual withdrawal of American troops and the process of "Vietnamization" were well underway. The 1970 draft call was the lowest since 1964 and in April Nixon made public a commitment to withdraw 150,000 troops within one year. The Paris peace talks, though making little visible progress, were underway Despite successful organization of a Vietnam peace march on Washington in November 1969, the Vietnam Moritorium Committee disbanded in April 1970 stating that there was "little prospect of immediate change in the Administration's policy in Vietnam."[1] The controversial Tonkin Gulf resolution was withdrawn, with Administration approval, at mid-year.

Despite the Nixon Administration's gradual "de-escalation" of the conflict, however, many Vietnam issues were still quite explosive. The My Lai massacre, for example, drew headlines throughout much of the year, amid charges of extensive Army cover-ups. Sihanouk was overthrown in Cambodia, followed by the massive South Vietnamese-American incursion into that country, which in turn occasioned a storm of domestic protest. The Kent State student shooting episode took place in May, followed by widespread university closings for memorial services and anti-war demonstrations. Later in the year the Army Mathematics Research Center at the University of Wisconsin was bombed, resulting in one fatality and extensive damage to the facility. Bombing raids on North Vietnam continued to inspire protests. The Senate Foreign Relations Committee remained a high visibility focal point for criticism of Vietnam policy.

In other national security areas, MIRV's were deployed for the first time in 1970 and the second round of SALT talks and other steps leading toward detente were undertaken. Preliminary moves were started toward improvement of relations with Communist China, resulting in major developments in the next two years. Middle East events were dominated by dramatic airline highjackings* and clashes between Palestinian terrorists and the government of Jordan.

Though the ARPA setting still was dominated by the continuing Vietnam conflict, the atmosphere was quite different from 1965 when massive U. S. involvement and campus-based protest were very new. War weariness had definitely set in and overwhelming pressures toward withdrawal had begun to take effect.

Lukasik's View of the ARPA Role

Dr. Lukasik, as previously noted, had been with the Agency since 1966 when he joined as head of the VELA office. He had thus witnessed the successes and set-backs of the Herzfeld period, ARPA's troubles with DDR&E, and the effects on the Agency of national policy decisions with respect to missile defense and the Vietnam War. He had also served as Acting Deputy to Dr. Franken and observed the demise of the view that ARPA should encourage academically-oriented basic research with only a broad justification of defense relevance. As Deputy to Rechtin, Lukasik could see the great difficulties involved in identifying and establishing new "revolutionary" projects and in achieving clear cut transfer successes of the type desired by the former Director. He had also, of course, lived through the Agency's AGILE and Vietnam traumas, the Mansfield Amendment restrictions on Defense research, and the many other disputes of the late 1960's.

A physicist with some administrative experience at the Stevens Institute of Technology prior to coming to ARPA, Lukasik became immersed in ARPA's internal management throughout his nine year tenure. Franken had been overtly uninterested in detailed management and had numerous clashes with Lukasik on this account; Rechtin tended to be deeply involved in ARPA's external affairs and in specific projects that interested him personally or demanded attention in the crisis atmosphere of the times. Considerable internal management responsibility consequently devolved upon the Deputy Director. Rechtin says that in his last year as Director, Lukasik gradually assumed almost all of the day-to-day responsibilities for ARPA management.[2] Perhaps because of these responsibilities, as well as personal proclivities, Lukasik was to be far and away the most introspective of the long chain of ARPA Directors in terms of his attention to ARPA's internal affairs. His meticulous concern with office organization, personnel, and budgetary and administrative issues was remarkably different from the approaches of all his predecessors.

As he assumed office Lukasik was, of course, very much aware of the morale problems on the ARPA staff in 1970-1971. He recalls the atmosphere surrounding the transfer of ARPA from the Pentagon to Rosslyn:[3]

* Two officials of the ARPA field office in Thailand were, incidentally, among passengers held hostage in Jordon after these events. They were released unharmed after a period of substantial Agency concern.

> [There were] terrible feelings that this is the end.... [While I was not in the alarmist camp, even I felt -- and I probably had a better view of what the issues were than anyone else -- even I felt that this was the beginning of the end.

Later Lukasik believes that he was able to turn the move to ARPA's advantage. Instead of harming the Agency, he believes that it removed ARPA from distractions, eliminated the Agency from the bickering over space in the Pentagon, enabled it to concentrate on its programs, supported the low profile image that he and Rechtin desired, and helped to solidify a feeling of identity:[4]

> It turned out to be one of the best things that ever happened to ARPA because, in fact, it was probably critical to ... whatever I accomplished.... [W]e stayed off and tended to our business.... In fact, it meant that almost all meetings in ARPA automatically became more efficient because if someone took the trouble to climb in a car and come all the way over to Rosslyn and have a meeting with you, it must have been something important and useful.... [At Rosslyn there was better space, circulation, etc.] So the building lent itself to communication.... Basically the move strengthened the internal feeling of identity.

Like his predecessors, Dr. Lukasik was inclined to take a strong view of the rightful status of the Agency. Asked why he took the job, Lukasik responded:[5]

> Because it [ARPA] was in trouble ... it was something that required change and could be changed. [The ARPA Directorship] is probably the best job in Washington for a scientist -- more prestige than NBS or NSF.

He conceived of himself as striking "the mean" between the ARPA's of Herzfeld and Rechtin. Lukasik was deeply committed, for instance, to Rechtin's principles of maintaining a low profile for the Agency and insisting on program transfer to the Services. On the other hand, he was just as deeply opposed to the office "barony" mode of operation and the involvement of the Director in the day-to-day details of individual projects. He was also more sympathetic to basic research and was less inclined than his immediate predecessor to make program transfers in large chunks, but the difference was more a matter of degree than of substance.

Lukasik firmly believed that ARPA's work was of first order importance; however, given the chain of events that had taken place since 1966, his approach to resurrecting a strong ARPA role was laden with defensive overtones. Lukasik may typically be seen as struggling to salvage a faltering effort in one office; gracefully (or sometimes abruptly) to cut losses in another; unobtrusively to grow a new program from modest beginnings; and to compromise with outside pressures (even at the expense of program flexibility) in order to avoid larger conflicts, or even just preserve some symbolic sign of ARPA's status.* For the new Director, the road to a strong ARPA was thus a winding one, requiring considerable ability to maneuver. Like Rechtin, he received no specific instructions from the DDR&E about how to administer ARPA, but he felt that he and Foster "resonated well" together, probably because both were physicists and had nuclear and weapons laboratory backgrounds and common professional acquaintances. Although the Herzfeld era "treaties" with ODDR&E were now forgotten, the management-conscious Lukasik became worried about the formal legitimacy of ARPA's tasks because of the cumulative pressure of GAO audits, Congressional inquiries, etc. He felt constantly badgered by "why ARPA?" questions and "who told you to do that?" criticisms. A hurried review suggested that about one-third of ARPA's projects had no known charter and others were informally justified at best. Perhaps over-reacting in the quest for "legality," Lukasik decided to use the old ARPA model: ARPA drafts a charter, DDR&E coordinates and the Secretary of Defense signs off. Six sample charters were submitted to Foster, who personally rewrote them. The thrust of his revisions was to narrow them and to express the philosophy that whatever ARPA was doing was <u>unique</u>, i.e., was not being done anywhere else in DOD. In Lukasik's mind, this was the "kiss of death" because uniqueness is so incredibly hard to prove. He dropped the whole charters exercise and the DDR&E never mentioned it again.[6]

While conditions never posed an immediate threat to ARPA's existence during Lukasik's leadership, he was clearly mindful of that problem. This probably helps to explain why brash statements of ARPA principles were less evident and less influential in guiding the ARPA program of the 1970's than were pragmatic adjustments to the Agency's difficult bureaucratic surroundings.

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* A trivial, but somewhat indicative, early example of Lukasik's concern with ARPA's status comes from a peer's recounting of his resistance in 1967 to Dr. Franken's thought of giving up the American flag in the Director's office, for reasons of decor. An official flag was assigned to ARPA in the Roy Johnson period when the ARPA Director's position was Executive Level III. The flag was retained when the position was later reduced to Executive Level IV. Lukasik reportedly felt that if once given up, it could never be regained. The story goes that when Franken checked the flag closely he saw that it indeed bore the 48 stars of 1958 and decided to retain this symbol of past status.

A very low profile posture for ARPA, "lest you get killed," was de rigueur for Lukasik's ARPA. He believed that it was folly to try to compete with ODDR&E as a center of expertise or as a technological spokesman. Likewise, highly visible assertions of independence courted Service attacks and complicated the transfer process. His belief in program transfer was related to this position: "I believe in transfer above all else, except survival."[7]

It was better to have transfer successes than to have credit for an idea, because as long as an idea remained in ARPA it was of no use. On the other hand, it was better to cement key Agency relationships than to push for a project transfer if the process of transfer could be damaging to ARPA, i.e., if there was reluctance on the part of the intended recipient to accept the proposed transfer. Lukasik was extremely aggressive in pursuing close Service connections for ARPA, especially with operational types, whom he felt had a much greater potential interest in ARPA than did Service R&D units. Moreover he believed that the operational military and the JCS would be likely to raise fresh, important problem areas that ARPA would otherwise overlook or not hear about:[8]

> I used to like to go to military locations because I really wanted to hang out with the military. Particularly the operational military. I avoided the military R&D people like the plague. Because they were guys just like me. Whether they were civilian or military they were just like me. [And] they weren't as good as ARPA. So, I tended to avoid the military R&D. But I liked to get out into [the field].

He felt that ARPA's "world" was really the world of OSD, JCS and the unified commands, all of which he describes collectively as "non-Service outfits." The commands, in particular, understood multi-Service needs and were most anxious for help. Lukasik courted them and believes that ARPA developed a sound record of response in meeting their requests. It is ironic too that Dr. Killian recalls that at the time of ARPA's creation, the science elite and others at the White House believed that the then brand new unified commands would need an organization like ARPA to meet their needs.[9] Dr. Lukasik cites the impact of some work undertaken for a command, at the request of the commanding Admiral:[10]

> [B]y the time ARPA finished it, he was Vice CNO, and I will also remember, with a feeling of 'having arrived,' when I received a letter from the Vice CNO explaining to me how the Navy was implementing 21 of ARPA's 22 recommendations and explaining rather apologetically when they couldn't accept the 22nd. You know, that's the way we got it, ... dropping in and out [of the commands]. So

> there was just in that last year [Lukasik's] just an absolute ... sort of all the waves added up ... and it was just a fantastically good operation with all of the military.

Lukasik concluded that by the time of his departure, the Service-related "wooing" operation that Rechtin and he had undertaken -- epitomized by the transfer doctrine -- in the aftermath of the ARPA survival operation in 1967-1968, had succeeded in every respect. ARPA now was being listened to by the Services:[11]

> It [ARPA] was recovering. As a matter of fact, it was probably a stage of influence we never had [with the Services]. You see, in the early days we were highly placed and had a lot of influence, but the Services were fighting us I mean there was the antagonism; you know, high placed but antagonism. Now ... we were not quite so highly placed, but we had kind of won our position. And, boy, they [the Services] really stood up and took notice [as] to what ARPA was recommending.

In keeping with the view that a strong ARPA must be able to live with the current policies, requirements and constraints of the Defense Department, a softening of some of the Rechtin era prescriptions for ARPA programs is observable in the Lukasik period. As discussed previously, this moderation of views could already be detected in Rechtin's final House testimony, which presented virtually every justification ever presented for an ARPA in one form or another.*

Among the changes which occur, there is a distinct moderation of the demand for rapid project transfer. Lukasik, for example, speaks of the transfer of projects after about an average five year lifetime in ARPA, as opposed to the 3-4 year turnover goal voiced by Rechtin. There is a recognition in the Lukasik period that some ARPA programs may legitimately be carried significantly longer than five years, with perhaps an average 20 per cent dollar turnover in ARPA projects resulting from some shorter transfers and cancellations offsetting longer term programs. The 20 per cent turnover figure was, incidentally, a highly pragmatic one, since ARPA calculated that this was approximately its current experience. Lukasik also felt that ARPA had suffered some needless loss of funds and personnel in the DEFENDER transfer. As Deputy Director he slowed down several transfer moves, e.g., the IDL's, to minimize disruption and to allow time for an

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* It is quite likely, incidentally, that Dr. Lukasik was largely responsible for preparation of this testimony since Rechtin was beginning to be occupied with his DDR&E responsibilities at the time the testimony was presented.

orderly replacement in the ARPA program structure. Thus ARPA moved away from "chunk" program transfers to "bite size" project transfers conducted on a more gradual basis. There was, however, no diminution in the basic emphasis on making transfers.

A second moderation of Rechtin era priorities is that ARPA's role in emphasizing "high-risk" projects of "revolutionary" impact is rather clearly relegated to the position of a rationale for only part of the work effort; moreover ARPA's role as a neutral, non-Service organization is given renewed emphasis.* ARPA still made a point of rejecting proposals because they are "evolutionary rather than innovative in nature,"[12] but the substitution of the word "innovative" for "revolutionary" itself indicates a subtle but deliberate change in perspective. The image that every ARPA success should entail a dramatic breakthrough is clearly missing. Reinforcing this shift in emphasis is increased attention to linking ARPA programs to Defense objectives not normally associated with revolutionary change in military capabilities, e.g., cost reduction, systems reliability and efficient utilization of manpower. To be sure, advanced technology might bring important and even dramatic changes to these areas, e.g., a sharp reduction in military training costs through use of computer-aided instruction techniques, but the use of the term "revolutionary" in this context would certainly constitute a considerable diminution of its meaning compared to earlier years.

Third, there is more willingness to tolerate 6.1 research. While supportive of the major transfer decisions in 1968-1970, Lukasik observed that some of ARPA's most talented people, many of whom were associated with basic research programs, left the Agency. While some "charlatans" managed to stay on in preferred programs, a number of "bright, intellectually honest people [in other programs] often suffered."[13] He also believed that they had been supporting some worthwhile things. Thus one sees in the Lukasik era a bit more toleration of basic research and some willingness to concede that "Defense-relevant basic research" is possible. This issue is discussed in greater detail below.

The dominant characteristic of ARPA in the Lukasik period is difficult to establish not only because of the subtle character of changes such as those mentioned above, but also because the Agency had acquired a rich legacy of cliches which continued to be used, but were recited either with little faith or with major qualifications. A prime example here is the

* In an internal working document prepared in February 1972, Dr. Lukasik describes proper ARPA assignments as having "one or more" of the following characteristics: high risk/high payoff, multi-service, feasibility demonstration, pre-mission assignment, rapid response, revolutionary potential, or an OSD requirement for central management. Lukasik is clearly saying here that there are multiple justifications for an ARPA assignment and that there is no single attribute that "must" characterize an ARPA project.

continued description of ARPA as the Defense Department's "anti-surprise" agency, with frequent reference to Sputnik and the need to avoid similar occurrences in the future. In fact, however, this rationale for ARPA's role appears to have been as much repeated out of habit and tradition as anything else. Dr. Lukasik's personal view on this question is revealing:[14]

> Well, if you read some of my earlier statements you would put me in the guarding against technological surprise school of thought. I found that that was an idea that did not wear very well. I said it a lot. I probably said it on my way out of ARPA, but I was really believing it less and less.... [Actually] I don't think that's a particularly important factor.... In the first place, nobody likes to be surprised, but surprise rarely hurts you.... You're at worse discomforted. Probably the prime example is the Soviet satellite; good case of technological surprise. [But] you know, in three years or four years we caught up and now we are preeminent in space. You may be surprised and surprise means that you may have to sweat a bit, run a bit and spend some extra money. But, rarely can a major power overcome another major power within the relatively short time that a surprise gives you, because if someone pulls off surprises -- another major power can catch up quickly in two, three, four, five years. You can't change international power balances in that time period. So, the way I finally came out is, 'surprise is uncomfortable but rarely, if ever, fatal.'

Dr. Lukasik's amplification of this view resurrects memories of the perspectives of Dr. Ruina and perhaps also Dr. Killian and the science advisors of the late 1950's and early 1960's. His interpretation is that to the extent "avoiding technological surprise" is meaningful it is in terms of keeping the nation on the forefront of militarily-relevant advanced technology, so that key policy decisions vis-a-vis military technology will be made from a solid base of knowledge. To illustrate:[15]

> Surprise ... is a measure of a difference in perception between two countries' technologists. One who not only thinks he can do it, but is in the process of doing it. The other who thinks you can't do it, because according to their technology, it's just not in the cards. Now ... the closest I can come to ARPA as an agency to avoid technological surprise, would be rephrased this way:

> ARPA is an agency that keeps this country at the forefront of as many areas of technology as are likely to be militarily relevant. So that if there's any judgment to be made in this country about the possibility of a state of technology, we will not be dealing out of weakness as our space scientists were in the late '50's, when they were sort of saying, 'well, you can do it, but we don't know what it's worth and it's pretty expensive, and so on.' So that's why we are pushing everything from lasers, to materials, to computers, to space technology, to -- you name it -- and pushing all these areas. So if there are any judgments to be made, our guys are not going to make the wrong technological judgments as to the possibilities.... To that extent ARPA is avoiding technological surprise, but that doesn't necessarily mean we have to do everything, that we have to do everything that's possible, that we have to do everything first. It's the weak form of avoiding technological surprise. It's what I would perhaps call avoiding technology perception gaps.

Dr. Lukasik went on to state that there should ideally be some mechanism or system to keep the ARPA Director aware of the status and potential of militarily-relevant technologies, so as to give him a more formal method of determining which advanced areas were most deserving of ARPA support. Ideally, as he put it, "We wanted to understand the limits of every bit of technology that would be relevant."[16] Despite the fact that such a mechanism does not exist, it is clear that Lukasik views ARPA's strength and mission as the selection and timely support of critical areas of technology (across the broad front of basic and applied research and exploratory development) and not really as preventing Sputnik debacles, the legend of ARPA's creation notwithstanding.

While using much of the old terminology and defending ARPA's importance, Lukasik also was forced to face up to the basic fact that the ARPA program was no longer dominated by so-called "Presidential issues," with major blocks of funding devoted to single large problems such as advanced ballistic missile defense, nuclear test detection, or even counterinsurgency. Both Rectin and Lukasik admit that their directorships did not really have such "Presidential issues." Portions of the old problem areas still retained no longer were of first rank priority for the Secretary of Defense or the White House and there was no momentum to mount multimillion dollar attacks on new problems of similar stature.* In Lukasik's perspective, the decline in Presidential issues indicates not that ARPA failed in any important respect, but merely illustrates that no technically-oriented agency can expect to have a continuing flow of major assignments on subjects that dominate the concerns of Presidents and Secretaries of Defense. National policy debates, that is, only occasionally hinge on developments in advanced technology which call for urgent, concerted programs, and when such debates arise they are only sometimes within the area of responsibility of the Department of Defense, e.g., the energy crisis may call for urgent advanced technology programs, but the mission does not primarily lie with the Department of Defense. Lukasik, therefore, rejects the concept that ARPA can realistically be organized around matters of Presidential importance. Dr. York, for instance, maintains that he was the most powerful of the DDR&E's because when he assumed office in 1959 most major national security issues were being defined primarily as technological issues.[17] This no longer is the case.

With the decline of Presidential issues, Lukasik turned to the somewhat less structured notion of monitoring developments generally in advanced technology as providing the basic rationale for an ARPA. As cited earlier, he described ARPA as keeping the country "at the forefront of as many areas of technology as are likely to be militarily relevant." To fill this broader role, the Lukasik ARPA becomes more diffuse and individual program elements become smaller, are less closely integrated with major missions, and cover a wider scope of activities. This trend is well illustrated by the preeminence of the Strategic Technology and Tactical Technology offices of the Lukasik ARPA, which were bounded neither by a specific technology nor a concrete mission objective and more or less divided equally between them the mainstream military functions of the Department of Defense to which technology could contribute. The remaining technology-defined offices (human resources, materials, information processing) may be regarded almost as "support" offices to the two large elements oriented more directly toward technological enhancement of tactical and strategic capabilities.** The greater diffusion of the ARPA effort and concentration on smaller discrete program elements in the Lukasik period naturally meant that the impact of

* The closest thing to this in the Rechtin-Lukasik period is probably the sizeable effort organized around the issues of antisubmarine warfare and maintaining the underseas deterrent. While this is a very significant DOD problem, it has not generated the kind of national policy debate that the earlier major assignments did and ARPA's role is less independent and is more closely integrated with multiple Service and other agency efforts.

** In fact, their amalgamation into a more general Supporting Research office was raised as a possibility during deliberations on ARPA's internal organization during the Lukasik period.

any given program element was likely to be less far-reaching than that aspired to by the larger "big problem"-oriented programs of the past. In the words of one of Lukasik's office directors, ARPA came to focus on problems where a successful effort might be "sort of crucial,"[18] a distinct moderation of earlier claims.

It can be argued, however, that the cumulative importance of these multiple, smaller programs can be equal to or greater than that of a few larger-scale attacks on first-order DOD problems. Given the Lukasik view that the flow of legitimate "big" technological problems is discontinous, and hence efforts to organize advance research around such problems would often be artificial, the more diffuse pattern of support for moderate-scale efforts on relevant Defense problems might appear to be much more effective. The question to be addressed about the Lukasik period, however, is whether, even if this approach is more realistic, it did not seriously reduce the Agency's ability to put a "critical mass" of support behind a new technology, lessen its ability to be innovative by tying it too closely to immediate Service problems, and generally to undercut the uniqueness of the ARPA approach.

To summarize Lukasik's view of the ARPA role, its major tenet appears to have been that for ARPA to be effective it had to establish a broad base of acceptance across its spectrum of Defense and Service customers. Acceptance might range from positive support and pro-ARPA advocacy to passive toleration, but broad acceptance of the Agency in many quarters was essential. Stripped of clear-cut charters which could be thrown in the face of a hostile bureaucracy and decreasingly utilized by ODDR&E as a direct challenge to the Services (as ODDR&E moved toward a more coordinative mode of operation), carefully cultivated relationships across the DOD establishment provided an alternative foundation for a workable ARPA. To this end, the ARPA philosophy -- or, rather, its succession of compatible and conflicting philosophies -- had to be adjusted, modified and presented in a variety of fashions acceptable to a diverse Congressional, OSD and Service clientele. In Lukasik's eyes, this development of a new foundation for ARPA (in many respects a prolonged exercise in bureaucratic politics and public relations) was not contradictory to the essence of the ARPA concept. If ARPA could remain on the forefront of Defense-relevant technological change, retain substantial flexibility to investigate high-risk and or overlooked technical problems, and sustain a commitment to research quality -- then it could tolerate restrictions inherent in its new mode of operation. What would be lost in the no longer sustainable appeal to Presidential Issue charters and the mystique of quasi-independent authorities would be compensated for by the protection and opportunities offered by multiple customers for the ARPA program. To a remarkable extent, given the depths of the ARPA crisis of the late 1960's, Lukasik succeeded in creating this broad foundation of Agency acceptance.

Support for Basic Research

Lukasik sensed the apparent contradiction between defense relevance and transfer on the one hand and "high-risk, high-payoff" R&D on the other. In an effort to reconcile these viewpoints, he reintroduced the notion of defense relevant basic research so common in the early ARPA and conceded that basic and applied research (6.1) was the most likely source of revolutionary or breakthrough ideas:[19]

> You are more likely to find the breakthroughs in 6.1 than in 6.2 because 6.2, by definition, [is] exploring issues that are more or less defined; you know, working with existing technology to see what they will do, and pushing them. And so the breakthroughs are going to be in the 6.1's. In materials we look for polywater because that would have been a super-duper kind of new material. We looked for room temperature organic superconductors because that would have been a super thing to do. We looked for new computer languages and artificial intelligence because that's going to do wonderful things like enabling computers to understand speech.... Those are all probing for breakthroughs. There are probably more breakthroughs per dollar to be found in 6.1 than in 6.2 and that's one of the reasons why you will never, or at least never should, reduce 6.1 to zero....

Having said that, Lukasik adds the companion conclusion that the 6.2 exploratory development work will have a much higher percentage of successes than 6.1 efforts. Therefore it makes more sense to emphasize 6.2 work: "I don't believe we were in the breakthrough business, really. You know, breakthroughs are important and you ought to invest to find them, but I don't think that's the name of the game at all."[20] Accordingly his rough rule of thumb was a ratio of about 80 per cent 6.2 work to 20 per cent 6.1.*

Given this outlook, it follows that Lukasik did not believe that DOD, as the largest user of scientific information, had some sort of moral obligation to support basic research:[21]

> I never bought that argument. I never bought it then [in the late 1950's and early 1960's] and I don't think I would buy it now. For one reason,

* As with Lukasik's desired rate of project turnover this was roughly in accord with historical practice.

> it has zero sales value on the Hill because the Hill takes a very simple-minded -- that doesn't mean wrong -- approach. They like ... a fairly neat, orderly Executive Branch. When they want to buy defense, they go to the Defense Department, when they want to buy natural resources, they go to the Interior Department, and if they want to buy science, they go to the Science Department. And so to tell them that the Defense Department is a user of science and it ought to put some of its defense dollars into replenishing the bank that it has been drawing from, the Congressional attitude -- not unreasonably is -- 'no, when we want to replenish the bank we'll give it to the Science Department and they'll replenish the bank....' So I think that replenishing the bank, that was a great argument in the late '40's and '50's, the sort of golden age of science. You know, we were still basking in the way science won World War II. The Defense Department was really the National Science Foundation of the country. The Defense Department had a very sensible approach to the support of science.... [Then] that was a great argument. [But] by 1970 it had zero sales potential on the Hill.... [There was] now a science department [NSF] that replenished the science bank....

Thus, for ARPA to support basic research there must not only be "good science" and perhaps breakthrough potential, but also defense relevance:[22]

> I really believe that the reason why you can't leave certain defense science up to the NSF, is the NSF is going to pick its priorities on the basis of science and it may turn out ... that the defense [problem] is ninth on that list, and it may be a first-rank for defense.... [Basic research] can be mission-relevant basic research and that's the essential point.

Determining defense relevance is, Lukasik admitted, a difficult judgment. On the one hand, the scientist searching for support is tempted to try to tie everything to some remote defense need, and on the other hand, some of the apparently most remote things ultimately turn out to be highly relevant. Given budgetary constraints, however, ARPA's criteria for relevance have had to be tightened. Lukasik's expression of this dilemma and ARPA trends in this regard is as follows:[23]

> There are too many, I think, shady scientists; that is, dishonest scientists, who will ... say, 'you've got your submarines in the ocean, and I've got my plankton in the ocean, so give me some money [to study plankton] ... and that's just not reasonable.... [But] there is such a thing as being too smart. There is such a thing as being too clever. There is such a thing as having too much confidence, and, you know, we just may find out that the way to find submarines is to ask the plankton! And ... we may be missing something. And I worried about being too clever, about being too much of a manager. By, you know, planning things and excluding some things on the basis of my own understanding or some expert's understanding. But, when money is tight you're kind of forced into that. And if you have an extra $50 or $60 million you begin to pick up plankton enthusiasts and things like that ... [which ARPA tended to do] ... we were buying all those flaky ideas, because we were too busy to sort them out. So, you know, when in doubt, if you have the money, buy it. When the money got tight you began to think and you just didn't buy a lot of things.

While budgetary limitations restricted the areas of basic research which ARPA could support, Dr. Lukasik felt that the agency was still able to provide institutional support to key organizations. The difference between the early ARPA policy on this issue and Lukasik's, however, lay in the need to satisfy more relevance criteria:[24]

> ... Scientists do not have a right to support in this country. You know, they have a right to live, they have a right to free speech, they have a right to a lot of things, but they don't have a right to the taxpayer's money. At least they don't have a right to the Defense Department's money.... So, yes, I want to build institutions, but I want to build the right kind of institutions.... [For example] if we wanted to build an institution that would improve the quality of intelligence analysis, not an institution in computer science, I [would] begin to get a little bit fussy [about applications] ... you just don't drop a million dollars on the table and say, 'when that's all gone, let me know, and I'll throw another $1 million on the table.' That's not only mismanagement, that's non-management.

Not surprisingly, given this perspective, Lukasik was not a believer in the "block funding" mode of institutional support that was used to underwrite the IDL's, though he professes appreciation for the reasons why this role was earlier accepted by ARPA. Moreover the "institutions" he chose to support usually were organizations like RAND, Lincoln and IDA rather than universities, and the work in those places seldom would be described as basic research.

Perhaps the most interesting aspect of Lukasik's description of ARPA's role in supporting basic research is that it highlights the extent to which issues concerning the level and form of support to basic research are so highly judgmental. Lukasik claims to support institution-building and recognizes that it is difficult to determine the potential utility of many basic research ideas, while insisting that relevance criteria have to be established. The criteria for what is relevant, however, seem to be largely dependent on current budgetary pressures and Congressional attitudes, so that much of what might have been judged as relevant and important, say, in Dr. Ruina's period might be totally unacceptable for ARPA support in Dr. Lukasik's period.

Management Philosophy

Lukasik, as noted, devoted a tremendous amount of time to questions of management structure and performance. At one point he rather forcefully solicited suggestions for organizational change from the ARPA staff, requiring formal papers on the subject from his office directors and convening them in a two day meeting to hear them discuss what they had written. He was sensitive to inherited morale problems and also to the baronial tradition of independent office directors. In his view ARPA was full of "independent baronies" which "had to be broken down" in order to institute proper management control.

While this may appear to be an overstatement, there is more than a grain of truth in it. The tradition of relative independence among office directors goes back at least to the Ruina period, when individuals like Herzfeld, Licklider and Godel exerted profound influence on the shape and direction of their respective program offices. This tradition of independence was strengthened through the years by the fact that successive Directors were inclined, or forced by circumstances, to give their primary attention to a few programs of immediate concern and to delegate large responsibilities to their office directors. This practice may have grown out of control in the last year of Rechtin's tenure -- the period of "absentee ownership" -- when Rechtin was increasingly occupied with his ODDR&E responsibilities and ARPA's office directors had unusually wide latitude to operate on their own. The "one on one" style of management, which Rechtin preferred, was definitely stressed in those circumstances. Lukasik felt that some of the Rechtin era office heads had too much freedom and when he was elevated to the directorship, some of them tried to perpetuate their status. He was critical of the abilities of a few senior people and, of course, most of the office directors were former peers, a condition that tends to highlight personal rivalries.

To illustrate that there was something to Lukasik's characterization of the baronial tradition, it is appropriate to cite the management philosophy of one of his office director contemporaries.[25] The way to start new initiatives, he stated, was to put "seed money" into established projects and quietly attempt to get something started without the approval of anyone in ARPA, DDR&E or elsewhere. If the initiative proved unproductive, it could be silently "deep-sixed;" if productive, it could be presented for approval as a kind of fait accompli. This office director felt that he had in the above an "investment strategy" which worked "despite" the ARPA Directors and DDR&E, to assure a continuously productive program of value to DOD and to the country. In his view, roles and missions conflicts in DOD (often complicated by Congressional attitudes) depressed new initiatives and the ARPA Directors were overly sensitive to these conflicts. Thus to live up to ARPA's role in taking risks, it was necessary to "bury" initiatives until they were viable and to "hide them from the Director of ARPA."

Lukasik was keenly aware of this aspect of his inheritance. It was another reason for his singleminded attention to matters of organization and management. And to illustrate the depth of the Director's feelings on this issue, he deliberately chose not to staff his new Technology Assessments office -- a small in-house think tank -- with strong idea men. Their purpose was to flesh out the Director's ideas, not promote their own.*

As part of the campaign to break down the baronies and assert control, Lukasik took a highly detailed interest in ARPA personnel policy. For instance, he personally conducted recruitment interviews for all staff rated at GS-12 and above, held entrance-on-duty interviews after hiring, and attempted to hold exit interviews whenever possible. He held rigorous twice annual personnel reviews and enunciated a belief in the value of relatively rapid staff turnover. While believing that "ARPA is a lightning rod and attracts lightning bolts," meaning very high quality personnel, it was Lukasik's philosophy that "the last thing ARPA needs is for a guy to stay, even a brilliant guy, because each has a limited repertoire."[26] As with each ARPA Director, Lukasik believed that getting good people was a priority task. Good people have good ideas and in turn attract programs and funds. With such people, the ARPA Director merely "blocks for his people; he doesn't drive, he blocks."[27] Even so, he felt that an ARPA

* Dr. Lukasik felt that this office was relatively ineffective in its intended role of starting-up new ideas and spinning them off to the established program offices, in part because it was very small and in part because it became a transitional "home" for ARPA staff in need of a billet.

program manager should have the same average tenure as the ideal average program lifetime, namely, about five years or less, because even the best people tend to repeat themselves. This turnover rationale was also helpful in speeding the departure of people in areas where the new Director sought to make changes. The reviews and interviews provided a means through which Lukasik could express his personal views on program needs, staff requirements, etc. and could establish his own authority should potential staff conflicts later arise. He estimated that he spent about one-fourth of his time on personnel matters.

Another Lukasik management control device was the requirement for a weekly report from each office director (a procedure instituted by Rechtin) and bi-weekly meetings with office directors and key staff. These reports and meetings were intended to be highly substantive, highlighting, for example, scientific advances, key upcoming meetings, the outcome of study groups, developments under specific contracts, etc. And Lukasik asserts that he "used to run through ARPA and just sit in people's offices and talk to them," and that his own door was always open in an effort to increase cohesiveness.[28]

Lukasik's overall management approach is perhaps best illustrated by the following statement:[29]

> [T]he key to command and control is, in fact, communication, because if there is good communication, that means you know what's going on. If you don't like it, you can stop it. If it's not what you wanted, you can correct it. They, in turn, are communicating with you so that if you are about to give a wrong order, they correct you in your misapprehension or your misperception of the situation. And you always know what the situation is, and therefore what needs are in order.

The Lukasik management approach emphasized the authority of the Director and his involvement in all key decisions, despite an alleged interest in recruiting strong, highly-qualified personnel. Though Lukasik claims that "every ARPA guy is a star" and that he "just blocked" for his people, he in fact appears much less inclined to delegate significant authority than almost all of his predecessors, and this fact is reflected in the style and operation of ARPA in the early 1970's.

Organizational Structure. The brief remarks above on changes in organizational arrangements noted the move to consolidate STO and create TTO, along with some supporting offices, symbolizing the general thrust toward discrete projects within offices with very broad functional titles. These moves also contributed to Lukasik's objectives in exerting control over the Agency, breaking down the baronies, and protecting it against abrupt "chunk-type" transfers or program cancellations.

Not only were Presidential issues gone, but Lukasik believed they actually had an unhealthy effect on the organization. He criticized "the crazy assumption built into ARPA" that "assignments came down from on high and you organized a new shop to do it."[30] This procedure resulted in baronies, in large, ultimately vulnerable programs, and in reduced flexibility for the ARPA Director to move his people around.

By slimming programs down to "bite size" and devising an organizational structure that tended to disguise or obfuscate who was doing what, it was possible to enhance internal control and reduce external vulnerability, i.e., to serve as a "survival recipe." The creation of relatively small, new program elements is often more successful than requesting increased funding in old ones, since Congress rarely increases an existing program element (though it may cut it). In addition, in the Lukasik structure the program elements could be handled almost any place, and he sought through a concept called "matrix management" to use people in different offices on a team basis, or to take advantage of special skills wherever they might be found. One man, for instance, might manage or coordinate all Navy-related work in ARPA, regardless of the offices in which it was located. To further enhance survivability, each 6.1 office was required to take blocks of 6.2 work, e.g., Behavioral Sciences was held at a $4 million ceiling for its basic research, but was permitted to add some $6 million in a 6.2 program element called Teaching, Forecasting and Decision Technology.

The net effect of this organizational approach was to maintain a low profile ARPA, emphasizing relevance and transfer, while giving little appearance of major change, i.e., just a "plain vanilla ARPA."[31]

Budgets. Part of Lukasik's mechanism for program control was dictated by outside requirements. Undoubtedly the most demanding of these were the three times a year budget reviews required by the annual funding cycle. As Congressional desires for presentations of greater detail increased (a general trend in the late 1960's and early 1970's), these budgetary reviews became even more thorough and time-consuming. To illustrate the extent of change, Ruina, Sproull or Herzfeld would come to the House Appropriations Committee (and other committees) with a budget request for $X million for VELA, $X million for DEFENDER, etc. Specific programs would, of course, be discussed in the ensuing testimony, but often not in detail, and usually without regard to funding history. Details were available on request, often in the form of subsequent transmittals for the record, but were not routinely volunteered. During Dr. Lukasik's directorship, in contrast, lengthy formal submissions were placed in the record as standard procedure. They would include a detailed description of each major program element, sometimes covering funding blocks of less than $1 million. The description would include statements on objectives, accomplishments, major contractors, related programs, program content over a three year period (last, current, and year requested), and other points. The internal budgetary reviews leading to the preparation of such submissions thus came to be very thorough exercises and permitted the ARPA Director to read into the details of program development much more readily than in earlier years.

Budgets were very tight during the Lukasik era, hovering around $200 million (See Figure IX-1). Belt tightening was in order and Lukasik was very adept at doing it, at a price, however, of "mortgaging the future." Various steps were taken to save what were felt to be good programs and to keep the real ARPA budget somewhat above actual appropriations. Among the techniques used were the following: (1) reducing unobligated balances gradually from around $50 million to zero, (2) reducing university forward funding to zero in major programs ($60 million from the IDL's), (3) reducing forward funding for non-university recipients, releasing roughly $100 million, (4) reducing the carry-over at Lincoln Laboratory (perhaps $15 million), and (5) speeding up transfer in selected programs (an estimated $100 million). Taken together these estimates total about $325 million, or roughly a $65 million annual "bonus" spread over a five-year period to be used for new starts and priority programs. Hence the "real" ARPA program during these years was arguably more on the order of $265 million.

As of FY 1975, most of this well had been pumped dry and ARPA's flexibility was severely reduced. Lukasik was able to do this efficiently in part because of his long tenure as Director. Rechtin believes that the post-Lukasik situation is dangerous:[32]

> When I was there we had more money than ideas. By the time Steve [Lukasik] left, the dollar situation was so bad, that they had far more ideas than money. And I [say] 'that's bad'.... So ARPA was in bad financial straits because of what the Congress had done to budgets as a whole, what the inflation had done -- the combination of things -- the real dollars went down. Not good.

In fact, Rechtin sees the seeds of a future crisis in ARPA's existence:[33]

> I don't know whether ARPA is going to be once again subject to the threat of being done in. Because the budget crunch is getting to be so bad now ... it wouldn't surprise me that all of a sudden [a Secretary] would ... decide to 'kill ARPA.'

Lukasik used other means to reduce the impact of declining budgets. For instance, the Services were invited into jointly funded consortia on programs that ARPA previously would have funded alone. This, of course, helps the transfer objective. On the other hand Frosch has suggested that in some programs multiple participants simply slow things down and DOD would be better served if ARPA were given the assignment and the funds to do the whole task.[34] Lukasik also reduced the amount of "high risk" work undertaken and tended less to fund multiple approaches to problems. The effects of these decisions on ARPA cannot be assessed at this time. Lukasik worked at reducing the size of the slush fund provided to the Deputy DDR&E's as well, in part because he felt they were using it primarily for rather pedestrian support services.

Lukasik did not complain about lack of funds. He obviously believed \$200 million was too low, but conceded that \$300 million would be too high. At the high end of the scale, Lukasik and his Program Management Director, Russell Beard, believe ARPA tends not to be managing well:[35]

> Russ used to say [that] when ARPA came down to the \$200 million level we were doing a much better and more professional management job. And he was right. So there is [such a thing as] having too much money. ARPA has had too much money in the past.... But it is true that when you are too constrained, you spend all your time worrying about the best way to lay out \$10k here and \$20k there, and that misses the point of ARPA.

Reflecting on his years in office, Lukasik concluded that "Basically, what ARPA needed was a little bit more money, not a lot more money."[36] It might be noted in this regard that the amount of contract money managed by a given ARPA program manager has decreased steadily and very substantially over the years. In FY 1963 (Ruina period), for example, there were \$3.7 million in contract funds per ARPA professional and in FY 1971 (beginning of Lukasik's tenure) only \$1.9 million. Thus ARPA funding would roughly have to double (with staff size held constant) to approximate the dollar management situation of the early 1960's. ARPA tolerated in that era, and was permitted to sustain, a much looser management approach than appeared feasible or desirable to Lukasik in the environment of the 1970's.*

<u>An ARPA Laboratory</u>. Dr. Lukasik was a strong proponent of the position that ARPA should not have its own system of laboratories. As he put it: "ARPA must take a vow of poverty. It must never own anything."[37] Speaking some seventeen years after the decisions not to seek such laboratories

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* In the "glory days" of the space program there were over \$13 million in contract funds per ARPA professional, <u>including</u> the IDA contract staff. Figures cited above include all professional staff; contract dollars per program manager would be significantly higher. Reliable historical data on numbers of professional staff serving as program managers is, however, unavailable.

Figure IX-1

PROGRAM BUDGET HISTORY DURING THE LUKASIK PERIOD
($ millions)

	FY 1971	FY 1972	FY 1973	FY 1974	FY 1975
Appropriations Requests	223	228	227	211	217
Actual Budget	209	210	200	194	202
Commitments to Agents	215	210	na	na	na
Requests By Program:					
Strategic Technology (STO)	66	78	79	73	75
Nuclear Monitoring	35	36	31	21	19
Materials	21	20	18	20	22
Behavioral Sciences/HRRO[1]	6	9	6	9	10
Information Processing/DIS[2]	27	32	39	44[3]	44[3]
Tactical Technology (TTO)	-	-	16[4]	28	36
AGILE/ODR	21	27	-	-	-
Advanced Sensors	23	9	13	8	-[6]
Advanced Engineering	17	18	13	-[5]	-
Technical Studies	8	8	6	4	2
Technology Assessments	-	-	-	-	5
Management Support[7]	-	-	4	4	4

1 Includes 6.1 (human resources research) and 6.2 (training, forecasting and decision technology) components

2 Includes 6.1 (information processing) and 6.2 (distributed information systems) components

3 Includes "advanced command and control and communications technology" element, conducted in conjunction with STO

4 Becomes TTO

5 Merged into TTO

6 Merged into TTO

7 Management support element added when ARPA separated from OSD and becomes a Defense Agency

were made, he regarded this as perhaps "the smartest principle that anyone ever built into ARPA."

The reasons for Lukasik's opposition to laboratories were essentially unchanged from the original rationale given for the decision against such facilities, namely, that they would create an unwieldy logistics tail and reduce the organization's ability to undertake new initiatives. Lukasik's view of the principle of not having an ARPA laboratory was violated in a major way only once. This was in the creation of the Range Measurements Laboratory (RML) at Patrick Air Force Base. While this was nominally a Service facility it was very highly dependent on ARPA funding, and the obligation to continue support became a major burden when the parent ARPA office (Advanced Sensors) was reoriented and finally phased out. The process of withdrawing ARPA funding and encouraging the Air Force to provide continuing support was a painful, drawn-out experience. It was partially because of this experience that a decision was made against the development of a national laser facility during the Rechtin-Lukasik period.

Parenthetically, a number of difficult organizational problems during the Rechtin-Lukasik period concerned phase-out of major institutional commitments somewhat akin to support of a laboratory. The list includes support for the university materials IDL's, termination of AGILE's field offices, phase-out of the Behavorial Science Cambridge Project, reorientation of support for artificial intelligence laboratories at Stanford and MIT, and divestiture of the ARPANET program. In each case, past commitments made change difficult and government-staffed ARPA laboratories would obviously have entailed even greater obligations.

Lukasik also was skeptical of laboratories organized around a given area of technology on the grounds that they tend artificially to limit a field. Laser technology, for example, is spread across a broad number of industrial and academic institutions, and to try to focus advanced research in the field in a central laboratory would, in Lukasik's view, be wasteful of these national assets. On this point, naturally, the Lukasik view is strongly endorsed by industry. Dr. Kantrowitz of AVCO, for instance, believes that the existence of government laboratories tends to restrict support for initiatives in private industry, given that they tend to have a first claim on funds and enjoy a protected status. Kantrowitz regards the ARPA principle of not owning in-house laboratories (which impacted on laser development especially in the Rechtin-Lukasik period) as perhaps <u>the</u> most important of ARPA's organizational virtues.[38]

As with the laboratory policy, Lukasik endorsed the executive agent concept. Agent performance varies across a broad spectrum and generalization is impossible. He is less critical than Betts, Ruina or Herzfeld and claims to have tried to make the agents "part of ARPA."

Contractor Critique of the New ARPA Style

Viewed from the perspective of many ARPA contractors the increased level of bureaucratic requirements, pressure for program transfer, pressure to eliminate forward funding and unobligated balances and so forth in the Rechtin-Lukasik periods is regarded as having had a decided negative impact on ARPA program effectiveness. A selection of comments by IPT contractors -- the IPT program having been substantially increased in both 6.1 and 6.2 funding in the Rechtin-Lukasik period -- is illustrative. One contractor, for example, notes a "steady drop in the general happiness level" of IPT personnel, with increased "struggling" over budgets, scope of work, and so forth. He notes decreased flexibility and authority for the IPT Office Director to make timely decisions and feels that this decrease in authority is related to ARPA's new management approach.[39] Another contractor ventured that ARPA support had taken a turn for the worse "in the last five or six years" with requirements for constant justification and rejustification, program plan drafting, etc. being a major irritant. This individual attributes earlier IPT successes to the fact that the ARPA staff was "constantly on the scene and we could discuss things as scientists as well as administrators," and he asserts that "that's one of the things that's breaking down now." He speaks of "a general break-down in confidence all along the line, which finally ended up making us waste almost a solid year of writing proposal after proposal of what we were going to do six months from now, a year from now, a year and a half from now, when we were working on techniques that we correctly believed would take four or five years to bear fruit...."[40] Another contractor faults the modern ARPA for beginning to over-structure projects, through pressing for more and more detailed work statements. He argues that this "gives relatively little opportunity for new ideas to come along" and states that highly structured projects are all right if what you want is "cheap coolie work, but that's not what ARPA wants out of us. Invention-to-order is quite difficult."[41] A fourth individual indicated that ARPA had become "bogged down ... they have these programs that have just gone on and on, more or less. They've changed a little bit, but not really significantly, instead of just really chopping some off and starting afresh with the new kids with the bright idea.... I still feel that I'm roughly the right age [for the ARPA group] ... and it's fifteen years later."[42] The erosion in ARPA's total budget and the elimination of the margin or "looseness" that enabled it previously to be able to "find some money" to support a bright new idea, quickly, parallels these views. As one observer puts it, it is "easier to get $5 million two years from now, than $50,000 now."[43]

All of these contractors, each from a different organization, give ARPA high praise for its record in the information processing field, including many aspects of the current program. In particular, they still contrast ARPA very favorably with other government funding sources, notably the NSF. A pervasive atmosphere of disillusionment, was however, unmistakeable (and not limited to IPT's area of R&D) and appeared to focus on a perceived lack of flexibility and innovativeness and, above all, the loss of a paramount focus on supporting high quality research on the technological frontiers. Ever increasing bureaucratic requirements tended to be seen as betraying a lack of faith in the importance and relevance of the work performed and sometimes even the motivations of the performers.

Thus, while the more cautious and bureaucratic approach of the ARPA of the early 1970's may have been necessary, given the Defense, Congressional and general R&D environments, ARPA has clearly paid a price for it. That price appears to be cast in terms of some erosion of ARPA's unique commitment to underwriting advanced research on its technological merits, be those merits general quality of research, importance to science or the significance of its implications to the national defense.

The New ARPA Directive

On March 23, 1972, a new Department of Defense directive was issued which superseded the long-standing December 1959 ARPA Charter and established ARPA as a separate Defense Agency.[44] Formally renamed the Defense Advanced Research Projects Agency (or DARPA), the main impact of the change was to separate ARPA administratively from OSD/DDR&E and return the Agency to the "direction, authority and control of the Secretary of Defense," i.e., to restore the direct relationship that had been lost when the December 1959 directive was issued. The new DOD Directive, however, provided that "staff supervision of DARPA for the Secretary of Defense will be exercised by the Director of Defense Research and Engineering (DDR&E), who will provide scientific and technical policy direction for DARPA activities." There were no significant changes in the functions assigned to ARPA and much of the wording of the earlier Directive remained intact. The new Directive did discontinue the requirement for formal written project assignments to ARPA from the DDR&E, but the latter continues to review and approve the ARPA program.

The new status appears to be regarded as relatively insignificant by nearly everyone familiar with the change. It seems to have been triggered primarily by interest in freeing-up OSD personnel billets and saving some OSD Operations and Maintenance (O&M) funds. These purposes were accomplished simply by removing ARPA from its original position within OSD and declaring it a "Defense Agency." By 1972, of course, a whole family of these agencies had sprung up and including ARPA among them was logical. That the change in ARPA's status was not regarded as especially important is partially illustrated by the fact that the new name, and the acronym DARPA, never really caught on, and the old designations remain in use except for formal letterheads and citations. As one senior ARPA official described the new directive: "All of us realize that despite what the charter says, we really are [still] part of DDR&E."[45]

At the time that the change in directives was made, the new charter was, however, regarded as having some potential effects on ARPA's future way of doing business. On the one hand, the resurrection of a direct relationship with the Secretary was felt to open possibilities for greater direction from this source and hence somewhat greater independence from DDR&E. On the other hand, there were some fears that by separating ARPA from OSD, the DDR&E would come to regard ARPA as a less "special" organization and would again begin to review ARPA programs in greater detail. That is, there was concern that there might be less resolution of issues on the ARPA Director-DDR&E level and additional "nit-picking" review from DDR&E staff.

Neither of these predictions appears to have come to pass. The DDR&E remains the controlling force for the ARPA program, but continues to give the ARPA Director considerable latitude to shape it. Whether this will continue to be the case in the future is unpredictable. Theoretically, at least, the ARPA Director and the Secretary could establish reasonably direct lines of communication. The 1972 charter changes certainly suggest that ARPA is no longer in danger of abolition and has strengthened its position as a continuing part of the DOD bureaucratic landscape.

PROGRAMS IN THE LUKASIK PERIOD

Dr. Lukasik's tenure as ARPA Director began with a continuation of the extensive program and office restructuring of the Rechtin period. Midway through his period as Director, however, this process began to slacken and relative stability gradually returned to the organization. As of about mid-1973, the new ARPA organization consisted of a Strategic Technology office responsible for about $70 million in programs; a Tactical Technology office funded at about $35 million; a Nuclear Monitoring Research office with a budget over $20 million; an Information Processing Technology office covering over $35 million in programs; a Materials Science office funded at about $20 million; and a Human Resources Research office with about a $9 million budget. There was a small additional budget for technical studies and for project management support. This is merely an approximate picture of the mid-1973 budget, but reflects the general program balance reached under Dr. Lukasik's leadership. In the following months, the principal changes were growth in the Tactical Technology office and the addition of a small Technology Assessments office.

Prior to describing some of the features and activities of these offices, it is worth repeating that Dr. Lukasik gradually separated the "program elements" as presented in Congressional budget submissions from a direct one to one relationship with ARPA's internal office structure. As a result, discussion of the ARPA program is a bit more complicated than in previous chapters. The change came about partially because of the development of "exploratory development" tasks in offices which were formally funded entirely through "research" funds. Since "research" and "exploratory development" (coded 6.1 and 6.2, respectively) are separately presented to Congress in DOD-wide budgets, the formal recognition that such hardware and systems development efforts as ILLIAC-IV and ARPANET were "exploratory development" activities required the creation of new program element categories. Thus the Information Processing Techniques office came to contain two program elements: "information processing techniques" (6.1) and "distributed information systems" (6.2); the Human Resources Research office similarly came to include "human resources research" (6.1) and "training, forecasting and decision technology" (6.2).*

In addition to the differences between program elements and ARPA offices, Dr. Lukasik also in some cases assigned management responsibility to one office for parts of a program element under the primary jurisdiction of another office, and experimented with cross office management techniques. This was done partially as a mechanism to ensure unified control over related work in separate offices pending formal consolidation (as in the area of underseas warfare, now largely consolidated under Tactical Technology); partially to fit work to existing staff capabilities; and partially to avoid the appearance of sudden shifts in the work effort. Given the turmoil in the ARPA work effort presented to Congress in past years, Lukasik preferred to change the scope of program elements slowly in order to emphasize stability, and ARPA's changes in internal organization of the work effort thus tended to move ahead of formal presentations about them. In this context it should be stated that there is nothing unusual in a Federal agency's budget categories not corresponding directly to internal office organization, and in fact this is probably the more common case.

The most striking example of this approach in the ARPA of the 1970's is ARPA's gradual entry into the undersea warfare area, long a private preserve of the Navy. Rechtin, Lukasik, Mann and others worked hard at making this penetration and consider it a major achievement. The research has been divided among several ARPA offices, e.g., STO, TTO, Advanced Sensors, and Nuclear Monitoring Research, according to Lukasik's new organizational precepts, and is difficult to summarize.

There has been periodic speculation over the years as to why ARPA was not asked to play the same role in antisubmarine warfare (ASW) R&D that it played in ballistic missile defense R&D. In part, this was due to a widely accepted belief that the oceans were inpenetrable, thus giving the offense a major advantage. It also reflected the unique position of the Navy as both the offensive and defensive user of the oceans. In the

* To be more precise, the 6.1 portions of the materials sciences, human resources, and information processing programs were formally presented as sub-elements of "Defense Research Sciences," which encompassed all of the Agency's basic and applied research, or 6.1 work, as formally submitted to Congress.

ballistic missile case Army had the defensive mission and Air Force and Navy were involved on the offensive side.

Unlike DEFENDER and its Pen Aids supplement, ARPA did not receive an underseas R&D assignment direct from the Secretary or the DDR&E. Instead ARPA by and large developed direct relationships with the Navy. The Navy's Assistant Secretary for R&D at the time ARPA commenced these initiatives, Dr. Frosch, was highly skeptical about ARPA's capabilities in this new area.[46] Indeed his attitude parallels remarkedly the early reaction of Service seismology experts when ARPA first began to dabble in that field. Rechtin shared that pessimism at the time, but supported his program managers. He now believes that ARPA has begun to make technical contributions:[47]

> [ARPA] has shown that underwater detection is a hell of a lot simpler and easier than anybody thought. And as a consequence, the whole picture of the submarines and the antisubmarines has got to change....

The rationale he recalls ARPA using with the Navy was classic DEFENDER:[48]

> Look, I don't think we know enough about it and I think it's time to go through it again and look at the physics again. It's been a long time, about 15 years, since anybody has taken a serious look at new instruments or whatever. C'mon, let's look at both sides of the equation, let's see if it's good or bad.

After obtaining Navy agreement, ARPA subsequently won DDR&E approval. The case there, paraphrased by a participant, was a hard line replica of the BMD argument:[49]

> That if the Navy ever finds a way to find submarines, the Secretary of Defense is going to be the last guy in town to know about it.... [T]hat's generally recognized in DDR&E.... You know, I still believe that's [the DEFENDER role] terribly important, the way ARPA should be.

Indeed ARPA's mere entry into this area was, in Lukasik's words, a matter of "exquisite delicacy."[50] ARPA, of course, did bring money (in the tens of millions) and contractors with "good tickets." It used Navy organizations solely as executive agents for the projects and concentrated on "helping out" the Navy in areas troublesome to it. ARPA emphasized providing assistance to the operational and intelligence segments of the Navy as well as to the ASW and strategic groups. ARPA does not have

DEFENDER's open-ended charter in underwater R&D, but is offering an interesting test case in this instance of the value of closely coordinated R&D in an area of deep single Service interest. The possibility of future differences of opinion, of course, is not negligible. The outcome of this experiment undoubtedly will have an important influence on ARPA's future.

The extended example above is only the most prominent of many contemporary ARPA efforts in which the ARPA program is difficult to delineate because of both increased dispersal of program elements within ARPA and more subtle relationships with Service programs. The summary of Lukasik period programs should therefore be read with an appreciation that many nuances of program structure are necessarily omitted. In addition, we have not attempted to assess ongoing projects in substantial detail, as historical perspective on their importance is as yet impossible. For purposes of succinctly summarizing the ARPA program effort of the early 1970's, the following description is organized around the ARPA office structure, as in previous sections.

Strategic Technology Office

ARPA's Strategic Technology Office, the successor to Project DEFENDER, had begun to take on its own character and shape by the time of Dr. Rechtin's departure. Some of the miscellaneous projects held over from the former effort were phased out, some reoriented and others given new priority and support. Additional new initiatives were generated as budget flexibility arose from the evolution of older programs past their peak funding requirements.

By 1971, the Strategic Technology Office (or STO) was described as follows:[51]

> The Strategic Technology Office is concerned with a broad range of science and technology directly applicable to the maintenance of the US strategic deterrence: in particular, the technological balance between strategic offense and defense, and to the technical problems of strategic surveillance and early warning.

The centerpiece of STO in terms of visibility and "popular appeal" was, by this time, clearly the high energy laser program. While, as noted in previous chapters, ARPA had had an interest in lasers for potential weapons applications tracing back nearly to the origins of the technology and had supported major breakthroughs in high energy technology in the mid-to-late 1960's, the exposure given the effort increased dramatically in the 1970's. Part of this increased exposure derived from downgrading the classification of the program (originally a special access program) and part from the development of vigorous Service programs utilizing ARPA technology (the Tri-Service Laser program established by Dr. Foster, as well as other major efforts). The fact that potential laser weapons were a "glossy" prospect with truly revolutionary overtones and that clear evidence of transfer to the Services could be shown made the laser program a particularly useful example to Rechtin and Lukasik in illustrating the kind of ARPA image and role that both sought to present to Congress. Though much of the work performed under the program was in fact highly esoteric from the layman's viewpoint (e.g., research in atmospheric absorption, beam propagation, plasma effects on targets) and though the Service programs were still rather remote from a practical operational weapon (particularly for strategic purposes such as missile defense), rapid technical progress and a highly saleable image put this effort at the forefront of the STO programs.

The attention given to laser developments was, however, a clear exception. There were numerous other major developments in the STO program, but they tended to be obscured somewhat by the classification of some of the major programs and their association with intelligence applications (reinforced by the eventual merger into STO of the strategic systems-oriented Advanced Sensors projects). To illustrate this problem, the Midcourse and Special Infrared Optics program, which was in FY 1973 the second largest effort in STO at about $15 million (compared to $20 million for lasers) tended for some time to be highly shrouded in secrecy. The program's purpose was described in an August 1973 statement as follows:[52]

> ... in the area of optics the project in Midcourse and Special Infrared Optics explores the areas of technology needed for advanced space surveillance, and defensive systems, in the long wave-length infrared (LWIR), visible, and ultraviolet portions of the spectrum. The program includes: sky, celestial, and earth limb measurements at operational sensor sensitivities which are defining for the first time the LWIR background environment. An earth limb measurement spectrometer with twenty-seven spectral bands and with an exceptional ability to reject spurious radiation, a critical requirement for definitive results, were [sic] to be completed in FY 73. In FY 74, ARPA will conduct rocket probe flights of high sensitivity prototype sensors. Active and passive measurements will continue to be performed and program definition studies for a synchronous satellite detection sensor are continuing. It is anticipated that this program will make major multi-Service contributions.

Even this rather general and not fully inclusive description was quite detailed compared to most previous unclassified statements of the work effort.

Thus, though STO's effort in space object surveillance and LWIR technology has been quite substantial and the results apparently significant, the effort has been treated with considerable sensitivity and given a consistently "low profile." This was also true of other major program elements of the STO effort, in part relating to the intelligence community. For the efforts in "special applications technology," "surveillance technology" and "advanced concepts technology," (totalling some $21 million in FY 1973 funding), all had the following declassified FY 1973 descriptions:[53]

> Program Accomplishments and Future Plans: (1) FY 1971 and Prior Accomplishments: [deleted]; (2) FY 1972 Program: [deleted]; (3) FY 1973 Planned Program: [deleted].

The point of the above "description" is to emphasize the degree to which the STO program came to differ from DEFENDER in terms of public exposure. While DEFENDER had numerous very highly classified and special access projects, the overall purpose of DEFENDER was given very high visibility and the thrust of major program elements within DEFENDER could readily be discerned on an unclassified basis. In contrast, the majority of STO program elements were not even described on a cursory basis in the unclassified FY 1973 submission, and it is very difficult for an outsider to gain an overall impression of the STO mission aside from the fact that it was working on advanced optical and electronics technologies somehow related to strategic problems. The difference appears to relate to the much greater focus of STO on intelligence aspects of strategic systems and also to the style and approach of the STO office director (Dr. David Mann throughout the period covered) and Drs. Rechtin and Lukasik. Given the high degree of negative public exposure received by ARPA in the late 1960's, the tendency of the 1970's appeared to be to avoid any aggressive publicity about ARPA's major efforts. At approximately $70 million in annual funding, or one-third the ARPA budget, STO continued in DEFENDER's role as the Agency's largest office, but the lack of visibility given to the effort was in keeping with ARPA's low profile posture. It should be noted, however, that in the view of the contemporary ARPA Directors, Foster and others, many of the current STO projects are of first rank importance and will eventually be recognized as such.

<u>High Power Lasers</u>. As noted above, research in the high power laser field became the centerpiece of the STO program, at least in the sense of high visibility. This prominence came from the successes of the program in the Rechtin period, the lowering of classification restrictions surrounding the program, and the inherent appeal of a radically new type of weapons

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the Director's management approach. In the 1960's, that is, it was typical for ARPA programs to contain a small number of "core" projects, around which a broader technology development effort would be satellited. One can point, for example, to LASA, VELA Satellite, PRESS, the IDL's, ILLIAC, Project MAC, and a number of others. GDL development at AVCO and United Aircraft served as such a "core" project in the laser field. These projects served to focus the effort, but on the other hand almost always eventually involved transfer or phaseout crises. Dr. Lukasik who, as noted, asserted that he "believed in transfer above all else, except survival," apparently felt that large, high-visibility, internally-developed projects were detrimental to the transfer process; that is, the more unified and coherent the ARPA program focus, the more difficult it was to transfer. In any case, the laser research program of the 1970's does not have one or two "core" projects which then generate broader technology development requirements, but rather looks toward Service, joint committee and DDR&E interests to provide requirements.

Project SEESAW. Project SEESAW, transferred to the AEC in FY 1974, was a sensitive, limited-access project which deserves mention in the ARPA History as the most enduring specific project ever supported by the Agency. The SEESAW concept, that of a charged electron beam of sufficient power and directivity in the atmosphere to serve as a mechanism to kill enemy ballistic missiles, was broached to ARPA in early 1958, shortly after ARPA opened its doors, and became incorporated into the ARPA program later that year. It was to be transferred only after fifteen years. Never funded on an especially large annual scale, it cumulatively became a multimillion dollar investment, certainly ranking in the top twenty discrete programs supported by ARPA.

The SEESAW program may be compared to two other ARPA efforts revolving around advanced ABM weapons systems concepts. First, it is obviously related to high energy laser weapons concepts, both bearing a sort of "Buck Rogers" death ray image. While the specific technologies considered were quite different, both held the potential advantage of speed-of-light "instantaneous kill," transmitting energy to the target via a beam, and both shared similar conceptual problems, e.g., how to propagate a sufficiently powerful beam, how to overcome atmospheric effects on the beam, how to point the beam, and how to track objects with sufficient precision to achieve direct hits. On the other hand, SEESAW was also quite similar to early exotic systems concepts such as BAMBI, in the sense that there was greater initial enthusiasm for relatively near-term device development. That is, there seemed at first to be some feeling that sufficient investment could overcome the technical obstacles, so that the issue of cost-effectiveness appeared to be almost as important as that of feasibility per se. In contrast, the initial laser work clearly had the tone of a long-term exploration of the feasibility of weapons applications, a flavor which was related to the very low power output of solid-state laser devices in the early-1960's and the apparent lack of breakthrough potential. This assessment only began to change with the development of gas dynamic laser technology in the mid-1960's, which then quickly led to advocacy of nearer-term weapons applications. In the beginning, however, there was more of a broad technology development approach associated with the laser program (which was also of distinctly lower priority in the first year or two of support for both programs).

Visions of the near-term practicality of a charged particle beam weapon faded quickly, however, and what kept SEESAW alive as an ARPA project for almost fifteen years was the continued interest of several prominent physicists, technological spinoff and the failure of research results definitively to establish the infeasibility of the concept -- the latter a "principle" instilled in the original GLIPAR program approach. Among physicists interested in the concept, the most notable advocate was Dr. N. Christofilos. He was, as previously noted, an unrelenting source of intriguing high-risk, "far-out" technological concepts, and is widely considered the "father" of the SEESAW concept. The concept, however, was initially suggested by a group of well-known physicists not including Christofilos, and was periodically reviewed by equally prominent panels (often composed of JASON members) who varied in their degree of optimism about it, but almost invariably concluded that it merited continued support. This kind of support from influential scientists was never achieved by BAMBI, HELMET and other exotic ABM concepts that were curtailed early in the history of the DEFENDER program.

On the second point, while optimism rose and fell over the program's history, thus making "SEESAW" an ironically appropriate code-name, the considerable technical difficulties encountered in the research were never quite conclusive in proving the concept infeasible. Christofilos was particularly influential in proposing highly complex technical "solutions" to each major obstacle which arose; each such solution requiring further intensive investigation. He died in the early 1970's, depriving the project of its foremost advocate and source of innovation, and his death appeared to have contributed indirectly to the final transfer decision. Rechtin said it seemed as if the charged particle beam work had been going on forever as of the time he took over ARPA, but he kept it alive: "I continued [it] probably beyond the point of reason."[57] He was asked why:[58]

> I thought it was high-risk. And that it was appropriate in the total ARPA mix, that the dollars they are asking for weren't that much, and the real risk was the management or financial risk of not spending enough at the right time. What I saw was the theoreticians were coming up with solutions and then more problems, and then more solutions, and then more

> problems, sort of indefinitely. And it was very hard for them to know which problems were really all that important. It's the old problem: If you don't start to build something, you don't know which problems are going to get you. [Or] which other ones you might as well forget about, because they didn't turn out to be important anyway. So it's very hard in that program to know which problems count. And until you build something, you didn't really have a feeling for the [real problem].... I was still worried that [I] wasn't generous enough at the right time. Now, if Nick [Christofilos] were still alive, would they have found their answer by this time? I don't know.... At the level it was going, nobody was making much noise to absolutely wipe it out. But it could have been below critical.... I would have over-stuffed [the charged particle beam project] had the national policy been one which said 'go for the defense.' Right now the international treaties say you are not allowed to do that. Heaven help us if the Russians do figure it out. But then we would have time enough hopefully, to madly scramble around before anything overwhelming would happen.

An AEC report published in December 1972 revealed that charged particle beam research never came close to producing an operational weapon and that the thrust of research, as the AEC began to take over the program, was still at a relatively fundamental level:[59]

> It is difficult in any research program to accurately judge the time required to achieve sufficient understanding, but we anticipate that July 1974, is a reasonable target date for completion of the above task to a degree that, together with the theoretical codes, we can make predictions about beam propagation over longer distances.

The accomplishments of the SEESAW program are difficult to determine and evaluate. Considerable theoretical and experimental research was conducted, notably revolving around the Astron accelerator at the Lawrence Livermore Laboratory, and there was apparently considerable spinoff to plasma physics accelerator technology and related fields. A modified research program under AEC sponsorship continues, not necessarily related to BMD applications. On the other hand there was considerable criticism of program management throughout the effort. It is not at all clear that this field of research was best supported through focussing on a very high-risk exotic weapons application, particularly given the resultant restrictions on professional access to data for purposes of peer group review, etc.

SEESAW was obviously an example of a high risk program of potentially revolutionary impact and its ambiguous history raises a number of questions concerning the realism of organizing an agency mission around programs of this type. The program concerned did not reach its ultimate objective during a very long period of support and it is very difficult to judge what constitutes success short of achieving objectives. In addition, the project underscores the difficulty in reaching a logical termination point in "high risk" projects, since conclusively proving that something on the fringes of advanced technology has absolutely no chance of working (or not being cost-effective if it does work) is an extraordinarily difficult proposition. Of course, even BAMBI has been continuously revived as a potentially viable concept, given changing technology.* What eventually seems to have killed SEESAW as an ARPA project was a combination of the loss of the project's primary advocate, constrained agency budgets and the new agency transfer philosophy, rather than an objective evaluation of the productivity and payoff of investment in the technology. Its history is an interesting companion to the laser effort: two high risk exotic weapons programs, one eventually blossoming and the other never achieving a final breakthrough.

Tactical Technology

Formation of the Tactical Technology Office was essentially a three stage process. The first step, reflected in the FY 1973 ARPA program statement prepared in the spring of 1972, was simply a renaming of the old Overseas Defense Research Office, which contained the AGILE program and the newly-designated IVORY TREE. The renaming had the immediate effect of reducing the visibility of AGILE's foreign research emphasis and also reflected the reality of program changes since the overseas component of the office was, in fact, greatly reduced. The second step involved merging the disappointing Advanced Sensors and Advanced Engineering Offices with ODR-TTO, creating a much larger and more broadly based office somewhat comparable to STO. The third step was liquidation of most of the programs of the three merged offices and their replacement with new initiatives. As a consequence of this latter process, the 1975 TTO bears scant resemblance to any of the earlier efforts.

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* E.g., Dr. Herzfeld in 1967: "We think the time is getting ripe again to look at the whole question [of BAMBI] because the costs of putting things in orbit have gone down dramatically, the reliability of space engineering has gone up dramatically, so that the overall cost of the system ought to come down significantly (House Subcommittee on Appropriations, DOD Appropriations for 1968, Hearings, 90th Cong., 2nd Sess., Part 5, April 3, 1967, 143).

To detail this latter process more closely, the ODR office inherited by Dr. Lukasik contained the following major programs: counterinsurgency research, counterpart development, small independent action force (SIAF) research, border surveillance, and small arms research. Of those programs, counterinsurgency research was basically dead when Lukasik took over, counterpart development mainly covered the time needed to phase out the field offices through 1971, and the SIAF and border surveillance programs struggled through 1972. Small arms research was supported at a declining funding level from about FY 1970 until it disappeared in FY 1975. Even the last of the initiatives taken in CDR appeared to have relatively little impact on the new TTO. Programs relating to low cost weapons development and to tactical nuclear warfare received modest funding for a few years and were all but terminated.

Advanced Sensor programs fared little better. The Vietnam-related projects were rather quickly eliminated. Research on tethered balloons lingered for awhile but was phased out by FY 1975. The Rechtin period initiatives collected under Advanced Engineering shared a similar fate, with the major programs on SEV's, floating platforms and Arctic research all eliminated by 1975. In brief, the three merged offices served primarily to provide a package of funds and some transitional projects to tide the office over while new initiatives were developed, and few of the eliminated projects terminated with the kind of program transfer success desired by Dr. Rechtin.

Termination of the Overseas Defense Research Office. By 1971 Project AGILE was clearly in process of termination, having been greatly cut back under Congressional criticism during the Rechtin years (from approximately $16 million in FY 1969 to $7 million in FY 1971). In response to AGILE's negative image, the name was increasingly deemphasized and the work by 1971 was described under the more neutral office title of Overseas Defense Research. By 1972 (in the FY 1973 budget presentation) AGILE was to be formally terminated and the Overseas Defense Research Office transformed into a Tactical Technology Office (TTO) with a program emphasis outside of the counterinsurgency area.

In 1971, however, there was still interest in salvaging something from the ruins of AGILE and to continue a meaningful overseas research program. To attempt to justify a mission, ARPA returned to a rephrased version of the AGILE rationale of the early 1960's, namely, the need to develop indigenous capabilities for self-defense in the developing countries including, in the jargon of the 1970's, "counterpart development." The attempted program revision, moreover, returned to the focus on hardware development which dominated AGILE's early years. Lukasik observed that AGILE's historical evolution from hardware to environmental research to sophisticated systems work was perhaps correct in theory, but that achievement was in fact moving inversely with that progression. He considered the RSSP, as he inherited it, to be a complete disaster.[60] His statement on the revised emphasis is as follows:[61]

> For a number of years, ARPA has, as part of its program in research and development related to counterinsurgency, undertaken work in the area of counterpart development. The rationale was to assist countries faced with incipient or active insurgency problems to utilize or adapt the US techniques of operations analysis, systems analysis, research and development, and operational test and evaluation to structure their forces, tactics, and equipment to meet this problem. Such an approach, while it is inherently a long range one, offers the possibility of building up indigenous capability for both military research and development and also encourages the utilization of in-country procurement and maintenance to provide a capability to meet this particular form of military threat....

This background and experience related very directly to the gospel of the new Nixon Doctrine:[62]

> [T]hat U. S. assistance will be oriented toward aiding the recipient nations to equip and defend themselves to meet external threats without the necessity of direct U. S. involvement or intervention. From an R&D standpoint, there are a number of actions that will be taken to continue implementation of this policy. These included the appraisal of the particular problems faced by various countries, the development or modification of U. S. inventory items tailored to such needs, test and evaluation of appropriate non-U. S. items, the development of appropriate procurement and maintenance specifications and training requirements for the use of such equipment, and the investigation of possible third country equipment sources. Such items include, as examples, vehicles for ambush protection, detection and location of caches, artillery spotting at long distances, special aircraft for use in rugged terrain where airstrips are unimproved or unavailable, low maintenance small arms, border surveillance equipment, and cheap lightweight armor. The emphasis in the program will be on hardware items with little emphasis on the "soft" sciences/policy planning kinds of studies that have been undertaken in the past in the counterinsurgency program.

As part of the return to a hardware emphasis, stress was placed on the contribution of technology to border surveillance (intrusion detectors, lighting systems, etc.) and on the related concept of battlefield sensors. With the exception of the final sentence in the above quotation, the language of the Nixon Doctrine approach was basically the point that Godel was trying to make in 1960-61.

This effort to maintain a major overseas research program centered around counterpart development and a hardware orientation failed, however, to impress the Congress. Of the $27 million FY 1972 request for the Overseas Defense Research program, $11 million was not approved by the authorizing committees.[63] This cut virtually eliminated any residue of explicit counterinsurgency research, broke the back of the new counterpart development program (which might have maintained the Thailand and other field offices at a significant level) and prohibited the development of major new hardware programs abroad. The component of work still categorized under the heading of AGILE dropped from just under $6 million in FY 1971 to under $2 million in FY 1973, the latter sum essentially covering the orderly phase-out of the ARPA field offices.

The remaining funds (collected together under a new project name, IVORY TREE) covered various previously established border surveillance and sensor projects, an evaluation of several hardware and organizational options for small combat units, a small arms assessment project, research on laser designators for tactical applications, and a study of tactical nuclear warfare delivery systems. Most of these projects were on the fringes of the original AGILE mission, if not completely unrelated, and many were totally U. S.-based. The name Overseas Defense Research hence was inappropriate to the mix of surviving projects and was closely associated with the formerly dominant AGILE program. This office title was eliminated within a year of the FY 1972 budget disaster.

In many ways the most interesting aspect of the last days of AGILE/ODR was the abortive attempt to return to a safer world of supporting indigenous forces through "counterpart development" focussed on hardware-related concerns, using the Nixon Doctrine as the policy justification for doing so. The much-publicized Nixon Doctrine approach of substituting indigenous for U. S. capabilities failed to persuade Congress of the need to support a renewed overseas defense research program in ARPA, just as Vietnamization, the major test of the Nixon Doctrine, ultimately failed to retain the continuing high level of support sought by the Administration. Even with its controversial behavioral science and counterinsurgency policy aspects removed, the ODR program fell prey to Congressional resistence to continuing foreign expenditures in Southeast Asia.

In retrospect, Dr. Lukasik feels that many of ARPA's Vietnam efforts, notably in the AGILE and Advanced Sensors offices, were not well-conceived or very productive. He attributes the pressures of "urgency" entailed in the war as largely responsible:[64]

> You've probably heard the remark that the urgent often drives out the important -- so I would worry a little bit about urgency -- especially in an agency like ARPA, because the urgent problem of this year has got to be solved by people like the military Services who have the problem and have the resources and have the dollars.... That was, incidentally, one of the reasons why so much of the money that ARPA put into the Vietnam War was not a good use of ARPA resources. Because there was very little of a fundamental nature that was done, because we were working on the urgent not the important. This is not to say that the War wasn't important from a national viewpoint, or even that limited war isn't an important problem, but one wants to be careful about getting trapped too much by the urgent.

Advanced Sensors. The ARPA Advanced Sensor program continued in 1971 to undertake rather wide-ranging research and exploratory development activities in optical and electronic sensors, most of which was tied to highly classified intelligence requirements and/or Vietnam applications. The heavily expurgated unclassified presentation of FY 1971 accomplishments (as contained in the FY 1973 budget request) suffices to indicate the breadth of program coverage.[65] The effort in optical programs contained a "measurements and technology program" in underwater imaging, a "laser induced acoustic energy" program also related to ocean applications, and a battlefield night vision program which in March 1971 was integrated with a tri-Service program.* In electronic and electromagnetic sensor technology areas, emphasis was placed on advanced "moving target indicator" (MTI) radars for various tactical applications and sensor technology for locating hostile electronic sources such as radars and radio transmitters. An unclassified FY 1972 Director's statement indicates other areas of office interest, notably development of remotely-piloted drone helicopters as sensor platforms, or as combined surveillance-strike platforms, and the use of tethered balloons as sensor platforms (both discussed in Chapter VIII).

The Director's FY 1972 testimony, however, indicated that problems were being encountered in this effort. Whereas the FY 1971 budget for advanced sensors was some $20 million, Dr. Lukasik requested only $9 million for FY 1972. This reduction was placed in a positive light:[66]

> In Advanced Sensors, we show a reduction of some $12 million in FY 1972. This decrease is due

* Cumulative expenditures on "night vision" were very substantial over the years and there is no doubt that continuing Service programs owe a great deal to the earlier ARPA effort.

> to the planned completion of several programs in FY 1971, the transfer of a number of programs to user agencies in the military services, and a broad appreciation throughout the services of the value of sensors. The increasing support of sensor R&D elsewhere indicates that ARPA's catalyst role should be reduced.

In fact, however, Dr. Lukasik was quite critical of the conduct and management of the advanced sensor program. One of his first major efforts after appointment as permanent Director was a major overhaul of the Advanced Sensors effort, resulting by 1973 in its abolition as an ARPA office* and the dispersion of its remaining functions between the Strategic Technology Office and the newly-formed Tactical Technology Office (depending on whether the work was primarily tactical or strategic in orientation).

The problems of the advanced sensor program were multifold in nature. First, as discussed in Chapter VIII, to the extent that Vietnam applications were a central focus (or that Vietnam was used as a test-bed for sensor developments) the office was affected by some of the dissatisfactions and irritations arising from that prolonged conflict. Some of the devices and platforms tested in Vietnam, moreover, encountered problems and failures which apparently led to considerable finger-pointing between ARPA and the Services and exacerbated the already substantial tensions arising from the unhappy war situation. Second, a number of the specific projects (such as NITE GAZELLE and tethered balloons) were clearly ARPA initiatives with very little Service or intelligence community demand for the research and development effort. These projects met some of the same sorts of resistance encountered by various early AGILE efforts, with ARPA being regarded as something of an interloper in others' preserves. Third, in gathering together technologies with obvious intelligence community applications, the Advanced Sensors office may have been simply too "visible" to suit the tastes of various potential users. Fourth, the Advanced Sensors office was headed by an aggressive and controversial director, whose style and mode of operation was felt by a number of ARPA observers to have created difficulties with potential user communities. Finally, successive Directors encountered problems of quality control in this office, largely because of its intelligence characterization and consequent immunity from adequate peer group review. In any case, despite some specific technical successes, the Advanced Sensors office failed to achieve an overall record of positive accomplishment and was regarded by some as a fiasco at the time of its disestablishment.

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* Due to the timing of the reorganization, however, advanced sensors was still contained as a line item in the FY 1974 request and disappears in the FY 1975 presentation.

The New TTO. As previously discussed, TTO was born out of the ruins of ODR, Advanced Sensors, and Advanced Engineering. By 1975, the major program element in TTO was an aggregation of Navy-oriented research programs (about 40 per cent of an approximate $40 million budget), which had few roots in any of the three "parent office" programs. Acoustic array signal processing, a major part of this program, was inherited from the Nuclear Monitoring Research office and a broad undersea warfare technology program was transferred to it from STO. About half the naval warfare program was developed from the inherited Advanced Engineering budget, but the only significant program retained and expanded appears to have been research on the design of a specific type of marine vehicle body initially conceived in the Advanced Sensors office. Some work in ocean monitoring (e.g., submarine location) had begun in Advanced Engineering, but was greatly expanded and redirected following the TTO merger. The next largest program in the 1975 TTO budget was a program in "target acquisition and identification," which conceptually relates back to the Advanced Sensors mission, but contains few specific projects from that office.

Major projects by 1975 included work on low-cost remotely piloted vehicles (RPV's), a development which rose out of Dr. Foster's interests and which was strongly supported by Dr. Lukasik, and a collaborative effort with the Army on the so-called HOWLS system (for locating tactical hostile weapons fire). Curiously, the latter was an area of work in which ARPA had engaged in the late 1960's in the Vietnam context and then transferred. It returned anew to this problem at Army request. The former program, low-cost "mini" RPV's, has elicited considerable excitement in DOD, as the successful development of such cheap vehicles for battlefield reconnaissance and strike purposes has far-reaching implications for tactical warfare strategies through increasing the vulnerability of expensive tactical radar and weapons systems.

In 1975 the TTO work most directly related to the old ODR programs is a $7 million research effort in "weapons technology and concepts," concerning advanced tactical weapons such as laser-guided anti-armor projectiles, and a $3-$4 million program in "tactical analysis." The land-warfare component of TTO tracing conceptually to ODR is thus around $10 million, greatly reduced from the $20-$30 million budgets which that office enjoyed at its peak.

In summary, by 1975 the TTO program had evolved to a point where it was about evenly divided between naval and land warfare tactical research, with a few programs applicable to both areas. There is considerable emphasis on sensors, in the broad sense of the term, a characteristic it shares with the current STO programs. This emphasis also relates a significant portion of the TTO program to the intelligence sectors of the Services, and program visibility has been reduced as a result. Most of the programs in TTO are quite new and their significance and potential for successful transfer is difficult to judge. In contrast to many of those in its "parent offices," the TTO programs tend to be conducted in close collaboration with the Services, many as joint endeavors. TTO is thus a fairly considerable break with the past in terms of content and style of operation.

Throughout its period of evolution, TTO suffered from rapid turnover in office directors, a factor that contributed to what has become an historically difficult attempt to settle ARPA comfortably into areas of tactical R&D. Currently, however, the office seems to enjoy very high morale and it is seen by some ARPA staff members as replacing STO/DEFENDER as the "lead" ARPA office.

Nuclear Monitoring Research

During Dr. Lukasik's tenure, the nuclear monitoring research office became involved in one of the most interesting public controversies of the entire ARPA history. The controversy touched on the issues of what ARPA had actually accomplished in the underground test detection field, its frankness in disclosing accomplishments and the very propriety of the assignment of the nuclear test detection mission to ARPA. The events and issues involved in the debate will be discussed in the next section. Before doing so, however, a review of the character of this program in the Lukasik period is in order.

Basically the Nuclear Monitoring Research office in the 1970's continued the emphasis of the late 1960's. This is hardly surprising given Lukasik's experience as the VELA office director. He maintained a continuing interest in the program as Deputy Director of the Agency. The changes in direction instituted in the Rechtin period were, therefore, as much or more Lukasik initiatives as Rechtin initiatives.

The principal change in the Rechtin-Lukasik office was a considerable broadening of the work program beyond the initial VELA assignment of developing means to detect and identify nuclear tests. By the time Dr. Lukasik became Director of ARPA, VELA Satellite had been transferred to the Air Force and ARPA's continuing role in this field was largely restricted to the area of underground test detection, i.e., research on seismic verification. By 1972 it was down to an annual funding level of approximately $10 million dollars, contrasted to $20-$30 million levels in some earlier years. ARPA research in this area was scheduled for termination by FY 1976.

The new program elements of the Rechtin period continued, namely, research on evasion of test detection and identification and on nuclear diagnostic techniques, and a variety of programs not linked to nuclear testing but located within the office because they somehow related to techniques or technologies which were associated with the VELA program. In the FY 1974 budget presentation[67] these included "acoustic array signal processing" (which applied the seismic array signal processing techniques developed in VELA to acoustic signal problems in the Naval environment, e.g., submarine detection) and "military systems survivability" (which applied VELA's experience in the geophysical sciences, derived from both the seismic detection mission and from Rechtin's "military geophysics" program, to such problems as rapid excavation of tunnels and hardening and vulnerability of buried military structures). In addition, the FY 1974 request proposed a research program on the military use and conservation of raw materials and research on technology exchange with the USSR, neither of which appears to have been in any significant way related to prior office missions or expertise.

Throughout the Lukasik period there were continuous problems in justifying those office programs that had no connection with nuclear testing. Rechtin's initiative in earthquake research, for example, failed to get Congressional sanction as a problem of sufficient military relevance to justify a Defense research program and was cancelled during Dr. Lukasik's tenure. Lukasik's initiative in hard rock tunneling met a similar fate and the entire "military systems survivability" program was phased out by the time of the FY 1974 budget request. The acoustic signal processing work was eventually transferred to the Tactical Technology Office, where it appeared as part of a more coherent program concerning undersea warfare problems.

The picture of the Nuclear Monitoring Research office in the early 1970's is thus clearly one of an office struggling for a mission. The reason for this lies in the fact that the core test detection and identification mission was felt to be reaching the point of diminishing returns, and termination of research on this problem was clearly envisioned. ODDR&E, in particular, had come to regard the VELA work as a tax that ARPA had to pay each year, to keep vocal test ban proponents happy.[68]

In fact, the FY 1976 termination date mentioned above was a postponement of a much more decisive termination planned in the spring of 1972. At that time, the FY 1973 request asked only for a little over $7 million for seismic verification and it was stated that "... most of the ARPA identification research goal will be achieved by the end of FY 1973. The program will be brought to conclusion during FY 1974."[69] Evasion research was also scheduled for completion in FY 1973. The remains of the VELA assignment were thus clearly set for termination. This development was, however, abruptly curtailed by a controversy which made termination politically impossible. Without the controversy and its aftermath, and given the difficulties encountered by the new initiatives, it appears very likely that the office would have been disbanded by about 1974 and its residual projects scattered to other offices, probably STO and TTO. The events preventing this development are described below.

The VELA Transfer Controversy. In the summer of 1970 (July 20-23) ARPA sponsored a series of meetings at Woods Hole, Massachusetts on the subject of the state of the art in seismic discrimination. This meeting was intended to be simply another low-key technical conference of the university seismology community similar to those sponsored by ARPA on numerous occasions over the years. Ultimately it led to one of the most difficult public "incidents" encountered by ARPA in its history.

The conference itself was a forum for the presentation of highly technical papers concerning seismological improvements as they might relate to nuclear test detection and identification. To the layman the discussion would have been highly abstruse, if not incomprehensible, and the Woods Hole meeting received no more immediate public attention than would be expected for any scientific conference, namely, none. Over the months following the meeting the papers presented were formalized and ARPA prepared to publish the proceedings as a matter of standard practice. The meeting had been conducted on an unclassified basis and there was no special sensitivity connected with this process.

The ARPA program manager in charge of the conference mop-up operation was, however, an exceptional and controversial individual. A highly respected scientist credited with some notable developments relating to seismic detection, he was also known to have a strong pro-test ban orientation. In the 1960's he had joined the military seismic detection program and was associated with the national operational test detection system. Possibly because of his test ban orientation (and probably also merely because there were several strong personalities involved), his career there was rather stormy, and in the late 1960's he transferred to ARPA's VELA program. In ARPA the individual's controversial role continued, e.g., he was a strong advocate of an unclassified "long period array" program (which might have enhanced detection capabilities outside of currently existing classified systems and might possibly have been used to buttress pro-test ban arguments). ARPA management, however, proceeded cautiously on the long period array program, and various incidents and conflicts arose. The individual concerned was therefore something of a gadfly within the nuclear test detection "establishment," but certainly a man whose views merited serious consideration and whose technical capabilities were frequently praised.

In any case, as publication of the Woods Hole proceedings reached completion, the program manager in question drafted a brief summary of the meeting.[70] Couched in rather technical terms, the summary was optimistic concerning the state of the art of nuclear test detection and thus tended to lend support to test ban advocates (though the layman could most easily have missed any such implications). The proceedings, including the summary, were then given a fairly wide distribution, with the approval process apparently neither totally adhered to nor entirely ignored. Whatever the case, it appears clear that the optimistic technical summary "slipped through" the normal procedures for public release, and would not likely have been approved had closer attention to its contents been given by ARPA management.

Following this release the Woods Hole report was picked up by the press as evidence of a dramatic breakthrough in nuclear test detection and as an indication that the last technical obstacles to signing a comprehensive test ban had been removed. On April 11, 1971 the Washington Post reported, under the heading "Tiniest A-Blasts Identifiable Now," that:[71]

> Such dramatic strides have been made in detecting distant underground atomic explosions that scientists can now discriminate between earthquakes and the smallest nuclear tests conducted either by the United States or the Soviet Union. These scientific gains are expected to have a sweeping impact on the diplomatic front and promise to remove one of the last obstacles to a ban on underground testing of atomic weapons. That obstacle is U. S. insistence on as many as seven inspections a year of the two Soviet test sites, and Soviet refusal to allow any inspections. 'There is absolutely no need for on-site inspections' one conservative U. S. arms expert declared. 'Any decision against an underground test ban from here on is purely political.'

Optimistic comments from Senators Church, Aiken, Gravel, Humphrey, and Muskie were cited in the article.

Distribution of the questionably-approved summary and the Post article created a furor within ARPA. While the Post had clearly exaggerated the conclusions of even the optimistic summary (which did contain qualifications and did not claim that all nuclear tests were detectable), ARPA management felt that the summary was not balanced and reflected too much the views of its individual author. Consequently, ARPA attempted to withdraw the initially distributed Woods Hole proceedings from circulation and to replace the "unauthorized" summary with a carefully-drafted approved version.[72] The replacement summary was significantly more conservative on detection capabilities, though it still reported seismic advances. Like the original summary, it was couched in rather technical language. As a result of this episode there were somewhat bitter personal confrontations within ARPA, resulting in the program manager leaving ARPA for a position in the Arms Control and Disarmament Agency.

After the initial round of publicity, the "Woods Hole affair" apparently calmed down a bit, and in late June the ARPA Director left for Geneva to provide technical input from the VELA program to the ongoing disarmament talks. The morning he was scheduled to give his presentation, which emphasized that there were still unresolved seismic detection problems, a story broke in the Washington Post and the International Herald Tribune that ARPA was attempting to suppress information on seismic advances. The story essentially reported accusations made by Senator Case of New Jersey and it amounted to an attack on the propriety of the ARPA Director's Geneva presentation. To cite the International Herald Tribune:[73]

> ... In a speech prepared for delivery before the Senate today, Sen. Case said that he was concerned not only because the Pentagon's Advanced Research Projects Agency had suppressed scientific data, but because ARPA's director would be on the U. S. delegation to the disarmament talks starting today in Geneva. 'I am concerned that the U. S. representatives ... might not be as forthcoming as they might be,' he said.
>
> His allegations grow out of the disclosure that ARPA rewrote the summary of a report on a mid-1970 conference at Woods Hole, Mass. where seismologists discussed the ability to distinguish underground tests from earthquakes. The new version substantially undercut the reported scientific strides discussed at the ARPA-sponsored symposium.
>
> ... In a letter Sen. Case has released, three seismologists from the University of California at San Diego, who saw both summaries, said: 'We feel that the original summary more adequately represents our views as to the present status of the discrimination problem.'

The most immediate repercussion of the above article was the severe personal embarrassment of the ARPA Director (which he views in retrospect as the worst humiliation of his public career).[74] Returning to Washington following the Geneva presentation, there were recriminations concerning personal responsibilities for this episode. ARPA-ACDA relations, at least those involving the ACDA division joined by the former ARPA program manager, were quite sensitive for some time.

The public exposure of the seismic discrimination issue subsided for a time following the June press articles. In October 1971, however, the issue again surfaced at special hearings called by the Joint Committee on Atomic Energy's Subcommittee on Research, Development and Radiation on the "Status of Current Technology to Identify Seismic Events as Natural or

Man Made."[75] At these hearings Dr. Lukasik, the ARPA Director presented (along with Dr. Romney of the Air Force, later to become a senior ARPA staff member) what is probably the most thorough unclassified review of seismic detection capabilities given to Congress since the signing of the Limited Test Ban Treaty. This is a presentation in which Dr. Lukasik takes considerable pride,[76] and which Dr. Ruina, generally pro-test ban in orientation, cites as an unusually frank and high quality exposition.[77] Lukasik, while detailing various advances in seismology, emphasized the detection problems posed by testing in various media which tend to "muffle" an explosion, and by various evasion techniques. On the other side of the controversy, Senator Case appeared at the hearings to restate his view that ARPA had downplayed advances in seismology, adding that a constant decline in ARPA funding for VELA from 1963 ($41.4 million) to 1971 ($12.8 million) indicated that the field had not been given adequate priority.[78] The issue of the replaced summary was discussed, and support for the original, more optimistic, summary by some of the conference participants was reiterated (only a small minority of the Woods Hole participants, however, ever publicly endorsed the original summary). One of the Woods Hole participants appeared to argue for a strong new initiative to negotiate a comprehensive test ban, based on his unclassified reading of the state of seismic detection. He went on to voice the opinion that the true state of detection capabilities was likely to be better than that revealed (including the points covered in the Lukasik testimony) on an unclassified basis:[79]

> [I]t is almost certain that the capabilities of the U. S. national monitoring system ... which are classified secret, when combined with present unclassified data, are considerably better than for the unclassified data alone.... We do not have access to classified information -- military, political, and scientific -- which could drastically affect requirements for a monitoring system. We cannot assess the capabilities of nonseismic means of intelligence gathering -- for example, the satellite observations and espionage -- and we do not know the capabilities of the present U. S. national monitoring system.

On balance, the government testimony at the JCAE hearings was impressive and defended the ARPA program well against its critics. The controversy did not die at this point, however, as Senator Case pursued the matter through the Foreign Relations Committee. This culminated ultimately in the successful introduction of an amendment into the Committee-approved Foreign Relations Authorization Act of 1972 to transfer the entire VELA program and its FY 1972 budget of $9,993,000 from ARPA to ACDA. In approving the Case Amendment (Section 302 of the Act) several arguments were raised.[80] First, it was held that ACDA had legal responsibility for issuing, arranging for and coordinating research relating to nuclear test detection (explicitly written into the act creating ACDA in 1961) and that to fulfill this mission ACDA should have operational control of the subject research. Second, it was argued that ARPA was in process of phasing out the research and that this reflected a lack of commitment to research that might lead to a test ban. Third, it was argued that there was a clear conflict of interest in locating VELA within the Defense Department in that this put DOD "in the position of controlling the development of the means by which underground testing c… be ended and serving as the advocate of the military importance of con…nued testing." The Woods Hole episode was frequently cited as an example of the distortions created by locating VELA in the DOD.

With Committee approval of the amendment posing a real threat of VELA transfer, a vigorous campaign was mounted to head off such action. Extensive pro-ARPA arguments were developed and used to support the positions of Senators arguing for DOD retention of the program. Senator Dominick of Colorado was to lead opposition to the Case amendment.

The pro-ARPA counterattack took place on several levels.[81] First, it was argued that ACDA simply could not manage the VELA program, since the $10 million effort was as large as the entire existing ACDA budget. ARPA's ability to use DOD-wide resources was cited as essential to the program and great disruption of the program was forecast if the VELA effort were to go to ACDA, which would be unable to use these resources. This argument was greatly strengthened when the ACDA Director announced his "strongest opposition" to the program and emphasized the difficulties ACDA would have in administering the effort.[82] Second, it was argued that ACDA already had thorough access to VELA program efforts and was fulfilling its research oversight function without requiring direct management control. The ACDA letter also accepted this position. Third, it was strongly asserted that to the extent major advances in seismic detection had occurred (as argued in the optimistic accounts of Woods Hole), such advances were due to the ARPA program. Claims that ARPA was suppressing research accomplishments were discounted with ACDA denials and the critics' assertions that there were major accomplishments were turned around to defend the program. Fourth, declining ARPA budgets were shown not to reflect declining priorities, but merely the fact that major hardware investments were required in earlier years (e.g., VELA Satellite and LASA) and that the program was now concentrating on less expensive analytical tasks.

The final and in many respects the most critical argument used to defend program retention within ARPA was a clear-cut DOD commitment to continue the VELA program. This commitment came through nearly identical letters to Senator Stennis and Representative Melvin Price from Dr. Foster, outlining a vigorous continuing VELA effort. The letter to Senator Stennis read, in part:[83]

[I]n continuing the VELA program, we will direct the program to the following tasks:

Categorize the geographical areas which give rise to anomalous seismic events and understand the mechanism of those events with a view to reducing the false alarm problem.

Design a worldwide seismic monitoring network utilizing options generated by previous VELA seismic research including automatic data processing of the large number of events at low seismic magnitude.

Develop treaty evasion and evasion countermeasures concepts for incorporation into the design of seismic systems and consider the impact of non-seismic means to deter the use of potential evasion techniques.

As you observe, the thrust of our future research will be directed toward urgent and relevant questions concerned with verifying a Comprehensive Test Ban Treaty. We believe that this is an important function of the Department charged with national security and one which should not be delegated. The Department of Defense has every intention, therefore, of pursuing these activities vigorously and to allocate the appropriate funding. I also have every confidence that the quality and relevance of the research will be consistent with the Advanced Research Projects Agency's excellent record in the VELA program to date.

On the strength of these opposing arguments, the Case Amendment was defeated on the floor of the Senate on May 30, 1972, by a roll-call vote of 45 to 33.[84] Almost two years after the Woods Hole conference, the ARPA VELA program was given a new lease on life.

In retrospect, the transfer crisis seems both to have revealed strong points about the VELA program's location within ARPA and to have touched upon some real problems. On the first point, the argument that ACDA with its broad arms control and disarmament responsibilities and limited budget could not hope to maintain a $10 million seismic detection research program appears highly realistic. Spurgeon Keeny, who was with ACDA at the time, said that his Agency actively and voluntarily opposed the transfer on these grounds.[85] The VELA budget was about equal to the total ACDA budget and ACDA knew that it could not protect the funds. ACDA also recognized that it lacked the people needed to manage the program and would not be able, bureaucratically, to establish such a competence. The agency felt it was doing other, more important things and did not want to take on anything new that would interfere with or disrupt that work. Finally, according to Keeny, ACDA believed that ARPA/VELA was not doing too bad a job: ACDA had access to all the VELA data and felt that ARPA reacted responsively to criticisms from ACDA. ARPA had been able to sustain the program some fifteen years, and VELA's location within a large R&D agency and its access to DOD resources were undoubtedly factors in this longevity. Though ACDA's opposition to taking the program may have reflected some natural Administration resistance to Congressionally-dictated change, there was considerable substance behind its position.

Second, the debate did highlight ARPA's major role over the years in advancing nuclear test detection technology, ranging from support for basic research in seismology to the VELA Satellite program. Endorsements for the value and objectivity of the ARPA program came from numerous sources including, for example, a strong letter of support from Dr. Ruina to Senator Stennis.[86]

On the other hand, and despite assertions that the decision had not been made final, it is quite clear that ARPA had planned to terminate the VELA program following FY 1973: ARPA's FY 1973 description states bluntly, "the program will be brought to a conclusion during FY 1974."[87] The VELA program thus appears to have been given a new lease on life because of the Case controversy and not despite it.* Closely related to this point, pro-ARPA arguments that declining funds did not mean declining priority appeared particularly lame. The FY 1973 budget (excising evasion research) was only about $7 million and there was clear sentiment within ARPA that the work was of decreasing productivity.

The most difficult question by far is the basic issue of ARPA's objectivity in the VELA program and the distortions which might have arisen out of ARPA's location in the DOD. With respect to the Woods Hole episode specifically, it is clear that the initial press reports went far beyond those proceedings in terms of optimism, for Woods Hole did not state that all or "the tiniest" nuclear explosions were detectable, but rather discussed seismic threshholds in complex technical terms which left open the possibilities of undetected tests in various explosive ranges and in varying conditions (whether or not such tests would be significant is another matter). Regarding the issue of which report summary was most representative of the tone of the conference, arguments on both sides can be presented. The original summary was evidently written by a single, rather controversial, individual, and was not endorsed by more than a minority of the Woods Hole conference members. The second summary was more thoroughly reviewed, but was certainly more a reflection of ARPA's after-the-fact view of the conference than a participant-generated document. Though it may not have been

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* One cynic even offered the opinion that ARPA may have manipulated this series of incidents in order to create a new program charter.

politic to do so, ARPA appears to have had the right to replace the view of one of its employees with another Agency view. The Woods Hole group did not produce its own summarization or conference-approved conclusions.

On the broader question of the objectivity of the VELA program, the debate raised several issues. First, there is the question of whether DOD interest in continued weapons testing (which was indisputably present throughout the late 1960's and early 1970's) affected the direction of the research. On this question there is evidence that work content may have been influenced. ARPA came to place very heavy emphasis on research to isolate evasion possibilities, and these possibilities tended to be given very considerable exposure, e.g., cavity decoupling, hiding in earthquakes, simulation of earthquakes. On the other hand, rather modest exposure tended to be given to the limitations or constraints on evasion techniques, particularly as applied to the Soviet Union, the potential partner in an underground test ban agreement. This is not to say that the technical research was not objective, but the selection of research emphasis appears to reflect very thorough coverage of problems which might arise in a comprehensive ban and relative silence on points which might serve to lessen those problems. An example which has been discussed in unclassified form is the issue of the muffling effect of testing in "dry alluvium," in which media a 20 kiloton test might be conducted with perhaps the normal signature of a 1-2 kiloton test in hard rock, thus avoiding detection by current instruments. What has almost always been omitted in discussions of this point is that there is considerable evidence that this medium does not exist in sufficient depth in the Soviet Union to pose a major threat (lack of depth meaning that the test would leave a crater detectable by satellite or other means). In the Lukasik JCAE testimony this limitation was vaguely referenced in one chart, but received little emphasis.[88] The point here is that the research may be quite objective, but public emphasis may have been skewed somewhat out of sensitivity to DOD reservations.

The case may be made, and was made during the VELA transfer debate, that any such sensitivity concerning a test ban is in the national interest because it is of paramount importance that national security considerations be thoroughly satisfied before signing an agreement. Indeed, the VELA of 1971 was not regarded by ARPA as a program directed toward facilitating a test ban. As stated in material prepared for use in the Senate debate, VELA "has not been directed either to achieving a nuclear test ban treaty nor to frustrating a treaty -- it has been directed towards providing the technical data base from which decisions could be made concerning the extent to which it is possible to verify a treaty."[89] On the other hand, the original mandate of VELA was to "undertake research, experimentation and systems development to obtain at the earliest practicable date a system for the detection of nuclear explosions both underground and at high altitude."[90] The reason for this urgent development of test detection systems was clearly, at the time, the facilitation of a test ban treaty.

Whether one views ARPA's move away from striving for a system at the "earliest possible date" to merely developing a "technical data base" as more or as less objective depends on where one stands on the test ban issue.

A Retrospective Assessment of VELA. The really remarkable aspect of the VELA effort is the relative lack of criticism of ARPA's objectivity in carrying out this research for almost a decade. Being a DOD agency, one might expect that ARPA's motives and performance would have been under constant attack. Aside from the Case incident, they were not. Successive ARPA Directors were sensitive to the problem, but apparently were not handicapped by it. Following is a typical response to the question "Was VELA ever constrained by DOD interest in continued testing?":[91]

> Not really. That was not an issue. We had to be very careful. All of the Directors and Deputy Directors of ARPA had to spend time thinking about how to present VELA results. But we could talk to whomever really mattered and we could say whatever we wanted to them. I felt that we never had to hedge on discussing detection capability; that is, what we could detect and what we could not detect.

Spurgeon Keeny takes much the same position. He believed that ARPA walked a rather narrow line, politically, between those who wanted a test ban and those who did not, and was quite successful at it.[92]

For all of its success, substantively and politically, ARPA never seemed to generate a strong clientele for its work. The university seismic research community, for instance, did not rise to the Agency's defense when VELA came under attack. Perhaps ambiguity about VELA's purposes, the relatively rapid turnover in program directors (in early years) and in program content, and the broader and more emotional aspects of the test ban issue each contributed to this phenomenon.

A final judgment on the value of VELA results is exceedingly hard to make because by the time the data were flowing in quantity, the subject had more or less died, i.e., achieving a Comprehensive Test Ban Treaty, as a national objective, had at best become "neutral" in significance. The satellite work was excellent, but limited in purpose. The underground research was probably quite successful, in ARPA terms. That is, VELA was in many respects a good example of the typical ARPA "measurements" program. Seismology was a primitive field, the techniques and instrumentation in use lagged way behind the other sciences, and the small number of outstanding people in it were not working on the issues of greatest interest to the test ban issue. ARPA changed all that with its "centers of excellence" approach, provision of modern equipment, a wholesale attack on reducing the signal-to-noise ratio, etc. ARPA has also claimed that its VELA program was essential to the signing of the Threshold Test Ban Treaty, through the advances made in test detection at teleseismic ranges. The criticality of ARPA developments to the Treaty, however, is virtually impossible to determine since these developments took place over a period of more than a decade preceding the Treaty, along with other non-ARPA advances, and the level of risk associated with a 150 kiloton threshhold given varying detection capabilities is subject to considerable debate.

VELA has been criticized for taking an unduly broad-brush approach and being too loosely structured or managed. Keeny, for instance, argues that VELA became "a business in itself," a sort of "timeless mission" with inadequate focus.[93] Despite the tremendous range of R&D work undertaken and the masses of complex data produced, policy-makers felt that ARPA failed "to put it all together," to develop "an integrated picture," and to propose a solution. Policy-makers saw a lot of technical inputs, but were unsure about what to do with them. This position is reminiscent of Dr. Ruina's retrospective view of VELA:[94]

> ARPA didn't push the underground test ban stronger than [its executive agent] was willing to let it go.... We didn't push it hard enough.... We didn't insist on opening up the data to enough people.... And we couldn't get large university groups and individual scientists to really get out good data.

On the other hand, ARPA rarely took on the task of "integrating" final systems solutions in any of its program. Roy Johnson got in trouble for thinking too operationally and successive ARPA Directors tended not to repeat that mistake. Dr. Herzfeld took ARPA somewhat closer to operational issues in some areas and likewise generated controversy. If ARPA pushes "solutions," so this theme goes, it runs the risk that its overall R&D mission and credibility could be reduced. Certainly in the late 1960's, ARPA had enough credibility problems as it was. The closest ARPA came to an explicit test ban solution probably was the LASA concept, and it failed as "the" answer. Lukasik was very clear that ARPA's VELA responsibilities stopped at the 6.2 boundary:]95]

> First, let me argue why it wasn't our job.... ARPA is most useful when it's essentially the cutting edge, plowing into the unknown, cutting away the fog, learning ... things, throwing the facts behind us.... [L]et's let the lesser people behind us catch them and do the dog work. [Developing operating systems] is a waste of ARPA manpower. I will even argue that ARPA isn't terribly good

> at it. [It's] totally un-ARPA like.... So I will argue that we shouldn't have done it, and we didn't do it ... and to the extent that we backed away from it, we were being sensible people who were sticking to our main job. [N]o one else was doing our main job and there are lots of people designing systems.

As the Lukasik period drew to a close many observers felt that ARPA had taken the R&D about as far as it could go, that the "technical" work had been done, and that any decisions about achieving a test ban were entirely in the realm of politics, i.e., it was a policy matter involving assessments of comparative risks that were non-technical in nature. Ironically, Lukasik believes that ARPA succeeded, quite inadvertently, in creating the rudiments of a first class nuclear test detection system. In his judgment, the combination of the Worldwide Seismic Network, the LASA installations, several Seismic Research Observatories, etc., in effect compose a system: "And so, curiously enough, even though we would argue on first principles that we shouldn't [design and build a system], it's also true that we did it."[96]

Lukasik considers VELA a showcase of why an ARPA is useful. Conceding the relatively amateurish position in seismic work from which ARPA started, it proved what an advanced research group can achieve. He likens its highly competent adversary in this field to a dinosaur which had, as noted in earlier chapters, both a reputation and a system to protect. ARPA could free lance and take risks, and did so. ARPA stuck its neck out and said satellites would work. It said that large signal processors would work, along with extensive computer support. It spoke out for the large array. Eventually most of the suggestions ARPA made were useful and they had practical implications. The satellite success, in particular, gave ARPA scientific credibility; in addition, it raised management questions about the need for a system of ground stations. The underground work had some similar impacts. As he put it: "The narrow-minded guys always lose because the broad-minded guys let new ideas into the antenna."[97]

The VELA program, unlike all of the other early "Presidential Issues," survives at a modest level of funding in the current ARPA. Work continues on wrapping up various loose ends relating to seismic detection of nuclear tests, evasion possibilities and associated topics. Partially as a result of the Case controversy and partially as an independent development, the VELA staff has become closely involved with the preparation of U. S. technical positions on seismic verification for presentation to the Committee on Disarmament at Geneva.[98] VELA is now small, closely linked to both the negotiations community and the seismic detection operational community and, in the Lukasik mode, very "low profile." It appears to have settled into the role of a competent, neutral technical program of continuing utility and modest ambitions.

Materials Sciences

By 1971 the long-debated transfer of the IDL program from ARPA to NSF was finally in process. The NSF committed itself early in the year to picking up the major share of IDL funding in FY 1972. Delays occurred in the transfer negotiations, however, and an agreement was not finally signed until December 24, 1971, with transfer effective on July 1, 1972. The difficulties in completing transfer appeared to relate to the NSF's own budgetary constraints and problems in fitting the IDL effort into the NSF's priorities and methods of doing business. Dr. Lukasik felt that Congressional action following-on the Mansfield Amendment was highly important in pushing the transfer through.[99] The key action was Section 205 of the House-Senate Armed Services Committee Report on the FY 1971 Military Procurement Authorization Bill, which stated that the sense of Congress was that a larger share of Government support of basic science be funded through NSF. This made it very difficult for the NSF to resist transfer since the IDL program fell so clearly into the area in which Congress desired the NSF to play a greater role.

With the elimination of the IDL program, the thrust of the Materials office during the Lukasik period shifted from broad institutional support to a number of specific technology development projects linked to potential military applications. The FY 1972 program,[100] for example, included research on amorphous semiconductors, devices which were anticipated to be less sensitive to radiation than traditional semiconductors and hence would contribute directly to nuclear attack survivability in many military electronics systems; investigations of high temperature superconductivity, intended to permit military systems to take advantage of the superconductivity phenomenon in operational hardware;* and research on polywater and other polymerized liquids, thought to have potentially unique properties of utility in military systems. Another important program consisted of research and exploratory development on the concept of the ceramic gas turbine. Ceramics could be used for efficient, very high temperature engines of obvious utility in aircraft and other military systems, provided that the critical limitation of brittleness could be overcome. ARPA's work on ceramics as structural materials has been credited with creating "interest among all parts of the research community [that] is sufficient to make ceramics succeed if it is at all possible."[101] Research on materials for use in various laser applications (notably laser "windows") was another significant effort. This was closely coordinated with work at the Air Force Materials Laboratory and other Service programs.

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* Superconductivity at very low temperatures is a well established phenomonon but obviously impractical in military devices. ARPA's work was devoted to investigating the feasibility of materials exhibiting this characteristic (highly energy efficient) at higher temperatures.

These and other thrusts of the reoriented Materials Office illustrate Dr. Lukasik's move toward "vectored" basic research, that is, basic research directed toward specific potential military applications. Much of the supported research was, indeed, still very basic in nature, e.g., the work on polywater and superconductivity, but the selection of materials fields to support was clearly more focussed on specific military applications than in earlier years.

While elimination of the IDL program resulted in budget reductions, the Materials office continued to receive substantial support throughout the Lukasik period, with funding consistently over $15 million.

Information Processing Techniques

By the beginning of Dr. Lukasik's tenure, the Information Processing Techniques office had grown to be one of the largest and most prominant ARPA undertakings. In FY 1971 the total budget for the office stood at close to $30 million, with $16.2 million in the 6.1 research category and $12.5 million in the 6.2 exploratory development category. The latter budget was expanding rapidly, reaching $18.9 million in FY 1972 (the total IPT budget approached $35 million). In addition, a new program element entitled "advanced command and control and communications technology" was established at the $4 million level in FY 1973 (and subsequently increased thereafter). It was administered jointly with STO and included exploratory development work on military application of packet switching technology and on command and control systems security. Dr. Lukasik claims credit for "re-inventing" the phrase command and control in ARPA about a decade after it was first used as a title for the IPT program.[102]

IPT was thus to be the third largest office within ARPA in the early 1970's, behind STO and the newly formed TTO. It was probably the largest effort in a single technology area and, since the bulk of the work was unclassified, it was one of the most visible of ARPA's undertakings.

Though a program of considerable breadth was supported by IPT, the two dominant program areas were clearly the exploratory development efforts in distributed networks (revolving around the ARPANET) and in parallel processing applications (the focal point being ILLIAC IV). As described in earlier chapters, each of these programs was developed in previous periods, but Dr. Lukasik clearly was a major supporter of both. Just as Dr. Sproull enjoyed the fruits of investments made during the Ruina and earlier periods, Dr. Lukasik, in this area, also appears to have reaped the harvest of earlier ARPA support. In particular, the ARPANET became well-established as an operating experimental computer network during his tenure and achieved major impact. The ILLIAC IV (while remaining considerably more controversial than ARPANET) at last became operational [illegible] was put to test in various applications.* The two programs tended to dominate the public image of IPT, much as laser research stood out among STO programs or as the time-sharing efforts at MIT's Project MAC dominated earlier IPT work efforts. The two programs were also somewhat unique in that ARPA was itself a substantial user of technical developments from each. ARPANET was used extensively by Lukasik for computer-based management control; and ILLIAC IV served as the facility for a major program involving modeling of potential inadvertent or intentional climatological modifications (resulting, for example, from large-scale military or economic activity), and is also being extensively employed in ARPA's ASW research (for use in processing data from underwater acoustic arrays). These appear to be the first important instances of ARPA being a prime user of its own technologies.

While ARPANET and ILLIAC IV were the most obvious IPT programs of the Lukasik era, much of the broad-based research effort of earlier years continued. MAC received substantial support throughout the period, as did advanced "artificial intelligence" research at MIT, Stanford and elsewhere. One does see throughout the Lukasik period, however, an effort to give considerably increased guidance and orientation to these programs, and hence a progressively reduced tendency simply to underwrite broad institutional research efforts and to permit institutional directors great flexibility in program development. A primary example of this greater program focus is the work in "speech understanding" (i.e., developing methods by which a computer can respond to verbal input), which was developed around a quite specific set of systems objectives regarding size of vocabulary, target demonstration date and so forth.[103] Programs in the development of automatic programming techniques, computer picture processing techniques, secure systems, voice compression, and others also gave far greater focus to the IPT program than was typical of earlier years. The previously described concerns with defense relevance and with discrete transferrable output obviously contributed greatly to these developments.

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* Dr. Rechtin's evaluation of ILLIAC follows the more or less standard ARPA pattern for explaining not entirely successful efforts, namely, expressing pleasure that certain technologies were "driven" while conceding that initial goals were not fulfilled:

> It turned out to be fairly expensive. By the time I was finished we'd spent more than 35 million [dollars], and I don't know how much they've spent now and it still doesn't do what it was supposed to do. But it also helped drive MSI (medium scale integration) and LSI (large scale integration) at the same time. It turned out LSI didn't work at that time. (Discussion with Dr. E. Rechtin, December 7, 1974.)

ARPANET. Without doubt, the most prominant IPT program of the Rechtin/Lukasik years was the ARPA Network, or ARPANET project. ARPANET also appears to have been highly successful, far less subject to technical criticism than the ILLIAC IV program, and far-reaching in its impact on advanced computer technology. Like ILLIAC IV a relatively expensive program, ARPANET has had a much broader influence on the field than parallel processing research, and almost any detailed reference to expanding computer networking technology repeatedly cites the importance of the ARPA program. Only ARPA's earlier work in time-sharing appears to have had comparable impact.

Computer networking, that is linking geographically separated computers for resource-sharing purposes, has a conceptual history going back to at least the early 1960's. Dr. Licklider, IPT's first director, developed an interest in networking as part of his broad approach to improving the state-of-the-art of interactive computing.[104] Robert Taylor, a subsequent IPT director, shared this interest.[105] Various small programs relating to networking were consequently established in the mid-1960's.

The program which was to become known as ARPANET, however, was established only in 1968, shortly after Dr. Rechtin's arrival. The concept's chief promoter, and by general agreement the individual with the most valid claim to be the "father" of ARPANET technology, was Dr. Lawrence G. Roberts.[106] Dr. Roberts came to ARPA in late 1966 from a position at Lincoln Laboratory to be a special assistant to the Deputy Director of ARPA. His responsibility was to provide technical advice to both IPT and other ARPA offices on computer matters. In mid-1969 he succeeded Taylor as director of the Information Processing Techniques office. In the tradition of Licklider, he was to be a strong and influential IPT director with a definite set of technical objectives.

In Roberts' words, he came to ARPA from Lincoln with the clear idea that networking, "getting these machines to work together," was the next big step in the computer field.[107] At the time, he stated, the gulf between physically separated computer facilities was resulting in very inefficient resource use:[108]

> [E]verybody was busy copying software [from other facilities] ... at Lincoln, where nothing ever got out into the world, I saw that very clearly -- that we needed some mechanism to move things out more effectively and make them available to the world without having to have them copy the text too ... and there was no basic communication system for this to happen on ... none of the carrier offerings were adequate in any way to support this, so I undertook the question of networking.

What Roberts did for the field of computer networking was: (1) to focus on a particular form of communications technology, "packet-switching," which appeared especially suitable for computer resource-sharing applications, and (2) to organize a substantial investment in this technology and in the hardware and software necessary to build a sizable prototype demonstration network. The technical details of these developments are far beyond the scope of this report. Suffice it to note here that the technology proved successful to the point that by 1973 the still-expanding ARPA Network had linked more than thirty computer centers, from coast to coast, for resource-sharing on a considerable variety of research and to an increasing extent, routine operational applications. Only fifteen "research nodes" were originally planned, but ARPANET expanded far beyond that number in response to requirements from potential users not engaged in network research. Thus the program came to contain a very substantial "service" function, while it continued to be operated and modified on an experimental basis. One net effect of the ARPANET demonstration was to convince many that the computer business of the future rested with interconnected mini-computers instead of with giant computers.

Like Project MAC's early CTSS time-sharing system (and later the MULTICS system), the ARPANET investment resulted in a high visibility demonstration of an advanced computer technology. As a result, it not only supported technological progress within ARPA-funded projects, but inspired and contributed to greater efforts outside of the ARPA program. Today, the technology is being widely developed commercially and considerable new work is being undertaken in academic settings.

Roberts sums up the contribution of ARPANET as follows:

> If ARPA had not been thinking ahead, people would have realized in 1972 that networks were absolutely necessary, and nothing would have happened. When I started the Network research, nobody believed it was a necessary and critical activity. But it turns out ... that '69 was the year it became economic to pursue networks, as opposed to just pure communications links, and within a few years afterward it became absolutely economically mandatory to do so.... So [ARPA's work] was clearly on time as far as estimating -- not by trends as I've done in retrospect, but by intuition -- the need within the field. I think the Defense Department has gained a number of years on that basis.[109]

ARPANET has been a clear ARPA success story, and is now widely acknowledged as such by leading computer scientists who at the time were skeptical of the large investments (over $10 million through 1969 alone) and of potential imbalance in the ARPA IPT program.

In noting the ARPANET success story, however, it must be observed that the program typifies the ARPA dilemma in large-scale technology development programs. Like many of ARPA's successes, ARPANET was much easier to initiate than to transfer. While early plans talked of a rather quick demonstration and rapid-spin off (possibly by 1970-71), ARPA was able to transfer the program, to the Defense Communications Agency (DCA) only in 1975. DCA provided a permanent home for management of the extensive service functions provided by the net, was an alternative to spin-off to the private sector (initially planned, but legally difficult), and permitted ARPA to continue networking research without the burden of maintaining a routine service facility. The transfer, however, was accompanied by large misgivings from the technical community associated with the project, which tended to see ARPANET as still in the experimental mode and more properly administered by a research agency.

ARPA's history thus again repeated itself -- a large-scale investment achieved large-scale impact and was accompanied by problems of equal scale in terminating the ARPA investment. In this case, the transfer problem derived in considerable part from the fact that the DOD does not have a home for computer R&D beyond the preliminary 6.2 exploratory development phase located in ARPA -- that is, there is no equivalent of 6.3 and 6.4 R&D categories for weapons system development. In the past these further development stages simply fell to the private sector (e.g., Honeywell developing the MIT MULTICS system commercially) and the DOD ultimately benefitted from ARPA's investment as a commercial customer, i.e., when it eventually bought improved computers on the market. In the heavily-regulated communications field this approach proved infeasible for disposal of ARPANET, and DCA was eventually asked to take over the Network despite the fact that it was not a fully developed operational system. Transfer of ARPA programs is thus inhibited due to discontinuities in the R&D process beyond the Agency's control, and the bigger the program in question the more such discontinuities are revealed.

Behavioral Sciences

By 1971 the reorientation of the Behavioral Sciences office away from controversial foreign area and cross-cultural research was complete. New efforts were quietly established in areas less likely to provoke strong emotional reactions. In conjunction with a DOD-wide change in 1972, the office was renamed the Human Resources Research Office. This appeared to be another effort to relieve the work of the sort of automatic "red flag" reaction that the term behavioral sciences often generated in Congressional committees.

Areas of research highlighted in Congressional presentations were also carefully chosen to reduce potential controversy and to stress military relevance. In 1971, for example, Dr. Lukasik emphasized two programs:[110]

(1) research in the psychological mechanisms of pain, which was justified in terms of its relationship to the treatment of military injuries and problems involved in the psychological suppression of pain during combat, and (2) research on "self-regulation" of bodily functions normally thought of as involuntary, with potential applications in such areas as "maintaining attentiveness and peak performance under difficult conditions." The justification given for both programs was quasi-medical in nature and rather far removed from considerations of either attitudes and values or broad policy issues, factors which were often at the center of controversy in earlier behavioral sciences work.

Other post-1971 programs in Human Resources Research similarly attempted to avoid the more controversial issues of earlier years. To illustrate, research on "analysis and modeling of complex systems" (basically the Cambridge Project at MIT) was focussed on "the development of a computer facility and associated programming techniques," and was described as having the purpose of improving data handling and analytical methods applicable to a wide variety of straight-forward DOD problems involving large amounts of data; examples include DOD personnel management, modeling of command and control systems, and intelligence trend analysis.[111] Despite the Cambridge Project's highly technical flavor, it came under considerable campus attack, in part related to general hostility toward DOD-sponsored university research and in part due to fears that improving the DOD's ability to manipulate large data bases could lead to various abuses. The project weathered the storm, but only after its continued existence at MIT had been severely threatened and at the cost of abandoning the planned official participation of Harvard University. In addition, some early plans to develop a large data bank of public opinion surveys in conjunction with the program were eliminated due to their controversial nature. Still, by emphasizing the development of computer data-handling techniques criticism was moderated and the program survived.

Another major program area, "training and manpower effectiveness," focussed on improvement of teaching machine technology in the context of a joint Service program for which a major objective was to examine the potential of teaching machines in reducing the cost of Service training programs. The program emphasized the development of both portable low-cost training devices and computer-aided instructional systems, e.g., in such fields as vehicle repair. While the program had possibly major implications in terms of training-cost savings, it was hardly going to become the center of a grand debate.*

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* Though even here there were some delicate moments. On one occasion, for example, a university student participating in a computer-instruction program using the ARPANET (involving a computer-aided conferencing approach) misused the system during the height of the Watergate crisis to urge Nixon's impeachment. After a minor "flap" ARPA brought the incident under control with little publicity.

The shift of emphasis in the Behavioral Sciences field thus was tending away from substantive research in social science and political science and toward research in data handling, analysis and presentation techniques, in many respects toward problems that could have been treated as a logical sub-element of ARPA's information processing office. To the extent that the individual remained a subject of research it was largely through research on "involuntary" processes (e.g., pain, self-regulation) unrelated to the sensitive areas of attitudes and values, or on the individual's interaction with computers, teaching machines, etc.

A second major program change, following an ARPA-wide trend, was to give increased emphasis to 6.2 exploratory development work. This category grew from essentially nothing in the late 1960's to perhaps 60 per cent of the HRRO budget in the 1970's. In the view of the HRRO director, Col. Austin Kibler, these programs were not only desirable in their own right, but politically essential:[112]

> [I]n a bureaucracy ... it's a dangerous game to lead solely with basic research.... Unless you can turn out some proximal products, you're soon going to get into political trouble when the inevitable questions come up as to 'what good has this been anyway' and end up suffering either in terms of budget or the very existence of the effort.

In adding exploratory development work, incidentally, the amount of basic research funded by ARPA was not reduced and, in fact, may have been somewhat increased. But Col. Kibler has stressed the importance of achieving fairly direct short-term research results in the human resources area:[113]

> I believe the hard sciences can 'get away' with more of the undefended high risk kind of things. That is, undefended by some more proximal outputs. The Congress and the public has come to expect magic in the long term out of physics. They can make big bombs. They can make magic computers, and if you just let these people muck around long enough they'll do that again. And I suppose they will. But the Behavioral Sciences don't have that kind of backlog of major breakthrough successes that will allow them the same operating license.

ARPA's retention, and actual significant expansion, of behavioral sciences research was not made possible solely by retreating to less controversial areas. In addition, both Congressional and Service attitudes had changed considerably from the bleak days of the late 1960's:[114]

> I sense now that the climate has changed a great deal and some interesting things have happened to help change it. The social strife for one thing ... the drug problem ... the change to an all-volunteer force that drove manpower costs sky high. And there were two interesting sides to that [the costs]: suddenly the engineering community that runs the Defense Department saw manpower costs eating into their goody bag, and [into] the dollars available to them for R&D and to buy hardware. So manpower problems became front and center in their minds.... [T]hey were, therefore, with more conviction representing behavioral science to the Congress.

In other words, whereas the constrained budgets of the late 1960's contributed to the attack on Defense behavioral sciences research as being marginally relevant, the continued budgetary constraints of the 1970's tended to legitimize behavioral science work that could be justified on cost-savings grounds. Skyrocketing manpower costs had replaced the Vietnam War as the villain in current and projected military budgets. Behavioral science -- or human resources research, to use the current nomenclature -- thus came to be viewed from a considerably different perspective than that which dominated the scene during the height of the Southeast Asia conflict.

LUKASIK'S DEPARTURE

Dr. Lukasik departed ARPA at the beginning of 1975, having served in senior management positions since 1967, far longer than any other Agency official. He left an ARPA with a budget about 20 per cent smaller than that of 1967, but roughly equivalent in size in terms of professional personnel (excluding foreign field offices) and numbers of contracts. Compensating somewhat for its decreased budget, the 1975 ARPA was heavily involved in joint programs with the Services and other efforts closely integrated with ongoing Service programs, part of which would have undoubtedly been funded internally under the old ARPA style of operation. Through tightened budgetary and management controls (reduction of unobligated balances, decreases in forward funding, etc.), the actual level of research effort had been further sustained at a relatively constant level.

The ARPA left by Lukasik in 1975 also appears to have become considerably less threatened than it had been in earlier years. Politically controversial programs, such as counterinsurgency and certain behavioral science research areas, had been shed and replaced by new efforts of lower public visibility and debate. New relations with Service organizations and defense agencies had been created, working level associations between ARPA staff and Service "customers" had probably never been better. Congressional criticism of ARPA declined and to the extent that difficulties in selling the ARPA program to Congress persisted, they appeared to relate primarily to general budgetary pressures rather than to specific objections to the program.* ARPA relations with ODDR&E and the rest of OSD tended to stabilize and there were fewer bureaucratic disputes to worry about. All in all, the ARPA of 1975 is much less visible than it had been throughout much of its past history, though interestingly it begins to be mentioned more frequently in the technical and trade press in the context of very specific programs and projects, probably a product of the Agency's heightened focus on discrete exploratory development projects with concrete programmatic and hardware implications.

Dr. Lukasik's departure came as no surprise because of his unusually long tenure as Deputy Director and Director. There had also been a change in the DDR&E over a year prior to his departure (Dr. Malcolm R. Currie succeeding Dr. Foster), an event which normally presages changes in the DDR&E/ARPA relationship.

Lukasik's successor, Dr. George H. Heilmeier, was appointed in late January 1975. Reminiscent of Ruina's background, he is an electrical engineer who came to ARPA from a post in DDR&E (Assistant Director for Electronics) where he had served since 1971. In addition Heilmeier had a lengthy pre-government career at RCA (1958-1970), bringing to ARPA a unique background in industrial research and development. His first statement as Director of ARPA before the House Armed Services Committee included the following:[115]

> I bring to this job a sense of commitment, a low tolerance for bureaucratic shuffling, a record as a market-oriented technologist and a determination to give the country a fair return on its R&D investment. I also bring a unique perspective to the job in that, in addition to my industrial R&D experience, I have also viewed ARPA from the vantage point of a position in the Office of the Director of Defense Research and Engineering where I was involved in the management of Service R&D programs....
>
> ARPA is a unique organization with a unique role. It is not another military R&D operation with the same charter as those in the Services. It was organized in 1958 to fill a need, and that need and unique role still exist. In discussions with the Secretary of Defense, the Deputy Secretary of Defense, and the Director of Defense Research and Engineering, I find that they feel as strongly as I do about the role of ARPA. Within the

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* Most ARPA budget cuts recently have been general non-directed reductions (say, five per cent) and have not been aimed at specific programs or projects.

> broad purview of potential Defense applications, they want an ARPA that ... [T]ackles the tough, the unique, the unconventional and is not afraid of failure when the prospect of a major payoff in national security is great....
>
> There will be failures. The purpose of R&D is to determine what will work, what won't, and why. When the Congress reviews the balance sheet at the end of each year, I invite them to examine the failures as well as the successes. But please look at the balance at the bottom. As Director, I believe that I can guarantee to you that the bottom line will show a clear gain in future national security ... a fair return for the public investment.

There clearly are overtones of Roy Johnson, Robert Sproull and Charles Herzfeld in that portrayal of ARPA's role, but also a new emphasis in the concept of a "fair return" on the ARPA investment. Once again a change at the helm has brought a new perspective to the Agency, and another chapter in the history of ARPA has begun.

CHAPTER IX: FOOTNOTES

1. Vietnam Moritorium Committee, Open letter of April 19, 1970.
2. Discussion with Dr. E. Rechtin, December 7, 1974.
3. Discussion with Dr. S. J. Lukasik, May 28-29, 1975.
4. Ibid.
5. Ibid.
6. Ibid.
7. Ibid.
8. Ibid.
9. Discussion with Dr. J. R. Killian, Jr., May 8, 1975.
10. Discussion with Dr. S. J. Lukasik, May 28-29, 1975.
11. Ibid.
12. Prepared statement of Dr. S. J. Lukasik for the Subcommittee on Research and Development of the Senate Armed Services Committee, FY 1975, (DRAFT), 6.
13. Discussion with Dr. S. J. Lukasik, May 28-29, 1975.
14. Ibid.
15. Ibid.
16. Ibid.
17. Discussion with Dr. H. F. York, April 4, 1975.
18. Discussion with Dr. M. Stickly, February 20, 1974.
19. Discussion with Dr. S. J. Lukasik, May 28-29, 1975.
20. Ibid.
21. Ibid.
22. Ibid.

23. Ibid.

24. Ibid.

25. Unattributed study interview.

26. Discussion with Dr. S. J. Lukasik, May 28-29, 1975.

27. Ibid.

28. Ibid.

29. Ibid.

30. Ibid.

31. Ibid.

32. Discussion with Dr. E. Rechtin, December 7, 1974.

33. Ibid.

34. Discussion with Dr. R. A. Frosch, October 31, 1975.

35. Discussion with R. W. Beard, May 23, 1975.

36. Discussion with Dr. S. J. Lukasik, May 28-29, 1975.

37. Ibid.

38. Discussion with Dr. A. Kantrowitz, July 15, 1975.

39. Discussion with F. Heart, March 20, 1975.

40. Discussion with Dr. M. Minsky, March 31, 1975.

41. Discussion with Dr. J. McCarthy, December 5, 1975.

42. Discussion with Dr. M. Pirtle, December 4, 1974.

43. Discussion with Dr. P. Franken, July 9, 1975.

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46. Discussion with Dr. R. A. Frosch, October 31, 1975.

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52. Commander's Digest, August 9, 1973, (Special issue on ARPA), 5.

53. House Subcommittee on Appropriations, DOD Appropriations for 1973, Hearings, 92nd Cong., 2nd Sess., Part 4, 945-951.

54. House Subcommittee on Appropriations, DOD Appropriations for 1974, Hearings, 93rd Cong., 1st Sess., October 5, 1973, 927.

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61. Prepared Statement by Dr. S. J. Lukasik ... Senate Armed Services Committee, FY 1972, op. cit., 28.

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71. Article entitled "Tiniest A-Blasts Identifiable Now" by T. O'Toole and M. Berger, Washington Post, April 11, 1971.

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80. Arguments for and against VELA transfer were reviewed in detail in Senate debate. See Congressional Record, May 30, 1962, S8552-S8564.

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106. Discussion with F. Heart, March 20, 1975.

107. Discussion with Dr. L. G. Roberts, April 23, 1974.

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110. Prepared statement by Dr. S. J. Lukasik ... Senate Armed Services Committee, FY 1972, op. cit., 13-14.

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Chapter X

CONCLUDING REMARKS

A REVIEW OF PERSPECTIVES

The preceding chapters in this volume make it clear that generalization about ARPA is especially difficult, if not impossible. The Agency simply cannot be tied up in a neat conclusionary package that purports to represent the essence of its seventeen years of operation. Indeed there appear to have been several ARPA's, each reflecting rather accurately the tensions and/or opportunities of the environment within which it was set.

At most, about one-third of ARPA's lifetime can be said to have been "normal." Much of the time it functioned in the midst of considerable bureaucratic stress. Outright abolition was widely discussed in 1959 and apparently quite seriously considered at the Secretary's level a decade later.

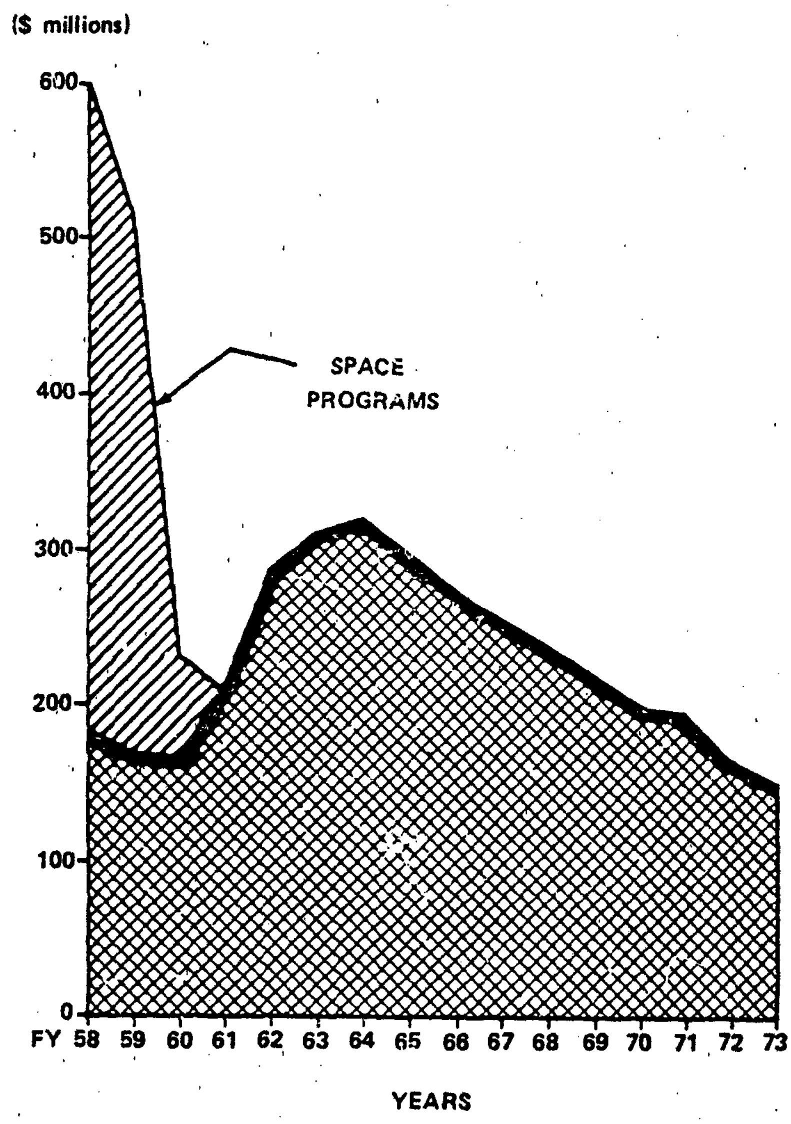
ARPA's tribulations have often been rather reliable indicators of forces and trends external to the Agency, although frequently those working within ARPA did not sense that fully at the time. The ebbs and flows of ARPA budgets, for example, reflected very clearly the ebbs and flows of DOD and RDT&E budgets generally. The relative rise and fall of the scientific elite and of the faith in science and technology's power to resolve all major national policy issues definitely affected perceptions of ARPA and what it was supposed to be doing. The evolution of the Office of the Secretary of Defense, especially ODDR&E, conditioned the uses to which ARPA was put. Many political and policy debates in Congress and the Executive Branch, e.g., ballistic missile defense systems deployment, nuclear testing and arms control policies, and the role of the United States in Asia, directly affected the Agency's programs.

During its first decade, ARPA's leadership tended to feel that the Agency was a unique organization in DOD with special ties to the Secretary and hence somehow immune from the impact of many of the forces and decisions that shape the activities of the Services and other parts of the Department. The assumption concerning organizational uniqueness was correct, but the derivation of immunity was not. ARPA was far more an integral element of the Defense Department than it cared to admit and this lesson was brought home rather severely in the post-1967 period.

There is no doubt that as the period under review in this study ended, ARPA was a much more constrained agency than earlier models. In fact, since 1967 it has been consistently receiving and even asking for less money, year by year. Figure X-1 illustrates this point, showing the downward slope of ARPA budget requests calculated in constant (1967) dollars. In the first ten years of ARPA's lifetime, the average Congressional cut in ARPA's budget

FIGURE X–I

TREND IN ARPA BUDGET REQUESTS
Constant 1967 Prices



requests was $2.6 million, the highest cut was $7.0 million and in five of those years there was no cut at all. By contrast, in the period FY 1969 through FY 1975, the average cut in ARPA's budget requests has averaged $18.2 million and the lowest of these annual Congressional cuts was $11.9 million. Since FY 1969 the ARPA program budget has averaged $205 million per year.* Obviously ARPA has been cut back (as have many other DOD RDT&E agencies and programs). A number of respondents' observations sprinkled throughout the remainder of this chapter implicitly, if not explicitly, are conditioned by this fact. A number of them speak about ARPA in the context of an agency with considerably greater funding levels than the Agency in fact now enjoys and with a "margin of flexibility" no longer available in the form of unobligated balances, forward funding options, etc.

Changes in ARPA's status over time are not particularly surprising, but we have been struck by the relative lack of discussion or debate either in the Secretary's office or the DDR&E's office about how to use an agency like ARPA, other than the essentially reactive attention that it has received when it was or appeared to be in trouble. Aside from the McElroy period, successive Secretaries have not paid much attention to it. Even the DDR&E's have seemed to be faced with a wide range of problems far removed from ARPA. They were unable or saw no need to give ARPA much time, especially Drs. York and Brown. Dr. Foster did for awhile, but the main reasons seemed to be a felt bureaucratic need to bring the Agency under proper management control and to use it to meet Vietnam emergencies. This absence of attention may correctly reflect the declining importance of crucial national security issues defined in R&D terms. At the least, the Sputnik era propensity to define issues almost entirely in terms of science and technology is clearly dead.

One may ask why Secretaries or the DDR&E's have not abolished the Agency. Aside from the fact that ARPA has done a number of undeniably useful things, a principal reason is probably its budget. If he so desires, a Secretary or a DDR&E can rather strongly influence the use of that money; it permits them, in theory, to handle things that "fall through the cracks;" and it may help them to deal quickly with problems that come up overnight, when there is not time to go up to Congress for authority and money. The phrase "may help" is used advisedly because, at present, as Rechtin observes, "ARPA's original charter and ability to move quickly, and take major amounts of money and throw it into something like [an emergency] -- and not have everybody stand around and argue about it -- is heavily diluted right now."[1] DDR&E's also have had a much easier time stopping Service programs than they do in getting the Services to start and sustain properly something that they do not want to do. York, for instance, found ARPA a great convenience for starting the Materials Sciences program. The Services might have done it, but ARPA did it: "There is just less argument with ARPA about getting something like that going, and doing it, than there is with the Services."[2]

* The most recent ARPA funding history, from which these data are derived, is reproduced as Appendix A at the end of this chapter.

Foster drew on that characteristic even more intensively, though usually for somewhat shorter range purposes. Note though that the usual DDR&E outlook on ARPA is conservative, restrained, restrictive. It is basically ARPA as a convenience rather than a necessity. This outlook relates to the discussion below of planning how best to use an ARPA.

The ARPA Role

A search for the essence of the ARPA role is an elusive one -- its charters have been both imprecise and comprised of multiple components. This has long been a source of continued "why ARPA?" questioning and a source of strength, in that it is impossible to pin down one single justification for the Agency that either makes it obviously indispensable or, conversely, permits it to be categorized as obsolete. As is clear from the preceding pages, ARPA has performed work of major interest to no Service, to one Service and to several Services. It has undertaken both very "high-risk" projects and institutional support programs for which the very concept of risk appears inappropriate. It has served OSD and the DDR&E very directly, supported work which OSD/DDR&E barely tolerated, and undertaken projects which interested no one outside of ARPA and the project performers. It has worked on issues of grand national policy debate, problems of interest primarily to some specific Service component, and projects incomprehensible outside of a technical laboratory. Its portfolio covers a wide range of both military concerns and scientific disciplines.

If pressed to reach a "definitive" definition of the ARPA role, we would be tempted to state that ARPA is the agency which, in principle, undertakes programs that: (1) have at least one of the characteristics usually attributed to ARPA work, namely, "high-risk," multi-Service, falls between Services, high OSD interest in central management, etc., (2) have no alternative home in the contemporary R&D bureaucracy, whether due to roles and missions disputes, budgetary constraints, administrative complications, or lack of interest, and (3) have some promise of more than marginal significance either within a technical field or in terms of Defense implications, or at least have a persuasive advocate to that effect. That is, an ARPA program is typically a product of a positive rationale for its assignment, a negative rationale for its not being assigned elsewhere (ARPA as a convenience), and a level of special interest in the substance of the program. All three characteristics are essential. A "high-risk," multi-Service interest program can be, and often is, undertaken on a joint Service basis and the Services normally can make a strong claim for this approach. Therefore, for ARPA to receive a "multi-Service" assignment there must be at least some transitory negative reason for the DDR&E not to choose this option, either due to administrative inconvenience or to policy reservations. Since ARPA does not have a charter to support routine R&D on a continuing basis, there is also normally a requirement to establish that there is something unusual or important about the prospective work (though the definition and threshhold of what is deemed important may vary considerably).

While the above may better describe the ARPA program than simply declaring ARPA to be the DOD's "anti-surprise" agency, it is obvious that it leaves room for considerable programmatic heterogeneity and varying emphasis. Not surprisingly, therefore, the numerous respondents who contributed to developing this history assessed the ARPA role from many different perspectives. Following below is a review of some of those perspectives, including ARPA's role in responding to major technological opportunities, filling gaps in Service R&D, providing flexibility and quick reaction capabilities, relating to "Presidential Issues," avoiding "technological surprise," and supporting basic research.

Responding to Technological Opportunities. Virtually none of the senior persons with whom we talked is prepared to say that without ARPA, various scientific and technological achievements would not have occurred. Such black and white views are foreign to the scientific temperament. Respondents, rather, commonly say that ARPA may have expedited the appearance of a particular technique, device or technology -- perhaps by several years -- but that one way or another most of the ideas supported by ARPA (or any other technical agency) would have come along anyhow:[3]

> [If you ask] how does it compare with other vaguely comparable elements of the Defense Department, in other words, how did ARPA manage defense R&D compared to how the Air Force or the Army or the Navy manages defense R&D, I think the answer is they [ARPA] do fairly well. On the other hand, if they had been eliminated, if they had never been invented, would the United States' defenses be weaker? I think probably not. Would they have cost more or less? Darned if I know. But it was a competent group who did their job reasonably well and who made some things easier for the other people in OSD.... I don't know whether [ARPA had] a better batting average [than other agencies] or not. I think ARPA has done fairly well in the past. I don't know whether ARPA still does well or not. I'm really not that close to it.... I think then [early 1960's] it was pretty good, but other people's batting averages were not zero. They [other agencies] might not be terribly high, but they weren't zero. There were good and bad groups everywhere.

Sproull remains convinced that without ARPA there would not have been a Limited Nuclear Test Ban Treaty, but other than that he tends to second the point of view expressed above:[4]

> I don't think you can say anywhere that 'without ARPA you wouldn't have had this,' but I think you can say that the ABRES program was a much more

> effective program because of ARPA, in that the Army ballistic missile Defense program [agency], ABMDA, was a much more effective organization and [made] much better use of federal funds because of the existence of Project DEFENDER, and because of the continued goosing and sort of technological audit and 'keeping honest' role of ARPA.

The simple act of expediting good ideas, of course, can be exceedingly cost effective, e.g., those who argue that without DEFENDER's success in highlighting flaws in ZEUS and suggesting an alternative approach, the ZEUS system would have been built at immense cost. Moreover, the cost effectiveness of accelerating such fields as computer time-sharing and networking or various areas in materials science may have been enormously significant, given the extremely broad potential influence of developments in these fields to the DOD and the civilian sector of the economy. This suggests that ARPA's role may be less one of supporting pure discovery or innovation and more that of choosing selectively from a market basket of ideas certain preferred items for accelerated development.

Dr. York, who is not one to argue that there must be an ARPA or that ARPA stood head and shoulders above other R&D agencies in terms of performance, agrees that it was useful and that it was characterized particularly by an ability to recognize good ideas.[5]

> The question of 'was there a pay-off?' can be asked at so many levels.... One level is that in a country like this with several million people working on defense questions and defense R&D (maybe a million persons, or half a million, I guess) it's just hard to imagine that if you take out any particular individual or any particular group of individuals that those same ideas don't just arrive somewhere else anyhow ... and probably not terribly long after.... There, though, the question is whether there is a management group that's listening and that can understand what it is being told; that's probably more important than where the idea comes from ... and there I think of ARPA, as being part of management, rather than originating. It's probably the ability of ARPA to listen to ideas, and to buy good ideas, that's more important than their ability to think up good ideas.

General Young, whom it will be recalled supported dissolution of ARPA in late 1959, believes that the Agency was excellent at selecting ideas and developing a sensible program with regard to outer space in the midst of the post-Sputnik chaos. Many space project ideas were floating around in

1958. What ARPA did was to structure or order incipient programs. As he said:[6] "ARPA picked the proper things to do, put the right amount of money on them, shaped them into coherent programs, and eventually turned them over." His characterization of the Roy Johnson ARPA has in fact been the ideal of most of Johnson's successors.

Dr. Sproull is very keen on this function of recognizing good ideas. He believes that if an agency like ARPA is properly handled:[7]

> [I]t will keep a lightfootedness that will enable [the Department it is in] essentially to continue to modernize itself, which a federal agency has a terrible time doing. [Having an ARPA enables a Department] to get a conduit for new ideas that may be unpopular ideas, challenging ideas, uncomfortable ideas, and contact with a world of ideas and people who may not be all that accessible to the standard part of the [Department].

As of the end of the period under investigation in this study Lukasik characterized all ARPA staff members as "sponges," soaking up ideas from everyone, rarely limiting themselves to a restricted number of sources.[8] The "high-risk" quality attributed to ARPA often has meant little more than a better than average willingness and ability to recognize and support ideas from unlikely sources that otherwise might not get through the "peer review" committees at the NSF or the layers of review boards and groups used in many R&D organizations, in the Services and elsewhere.

This ability to recognize good ideas ties in with York's view of ARPA as playing an important role in the "idea exchange mechanism" at high levels within the DOD and between DOD and the outside world. For many years ARPA was willing to support new or high risk areas of research and to make the results widely available to those working in R&D. This, according to one of our respondents, is the only way to advance the "technological culture." [9] His model was the advanced BMD technical community that ARPA supported and stimulated so successfully. Even though much of that work was classified, ARPA went to great lengths via paper circulation, information centers, symposia, special study groups (with broad participation from university, government, not-for-profit, and industrial people), supporting alternative approaches to technical problems, and other devices to make the data available and to solicit debate.* The combination of ARPA's very low-profile

* This was true even for the highly sensitive penetration aids work, e.g., ARPA arranged for relatively wide circulation of its compilation of experimental reentry vehicle performance data specifically to encourage a "self-cleaning" system, that is, one in which there were incentives such that corrections, modifications and up-dating would be almost automatically forthcoming from the most knowledgeable participants.

policy since 1968-1969 and its greater involvement in intelligence related R&D in the 1970's has perhaps reduced this characteristic somewhat, but ARPA is still generally regarded as superior to other agencies in arranging the exchange of information and ideas within communities of interested scientists and technologists. The absence of central program themes in ARPA and the recent tendency to support relatively small, discrete projects and program elements, however, might be expected to reduce this feature of ARPA's style unless these projects come to coalesce around a few major disciplines, fields or missions.

If recognition of good ideas is a reasonably continuous hallmark of ARPA's performance over the years, it follows, as many contend, that "good people" -- staff, consultants and contractors -- are the key to the Agency. This is a truism valid for any organization, but many take it to be the distinguishing characteristic of ARPA.

Every ARPA Director has unusually strong, positive words to say about the quality of the ARPA staff he directed. We have also found, to almost the 100 per cent level, that every ARPA professional considers his tenure at ARPA the highlight or one of the highlights of his career. This includes some who left angry, or quit because they disliked a Director or office chief, or resigned over the Vietnam War or other policy differences, or who departed because of differences over program content or direction. It is little short of amazing to find such consensus, expressed in such a forceful manner.

The common denominator running through the opinions of both the happy and the disgruntled appears to be that each was able to immerse himself in the substance of some work that he thought was significant and interesting, feel that he had played a definite role in shaping it or saving it from its detractors, and believe that the outcome of his efforts would be of above-average value to a scientific field and/or to the DOD. To illustrate this point, we cite at length an ARPA program manager who lived through the Agency's most difficult days in the late 1960's and early 1970's, as he assesses his role and the Agency's role:[10]

> ARPA is growing older. There's no doubt about it. There's more red tape, more bureaucracy and less autonomy and less rapidity of response than there used to be.... [I]t's grown since I've come on board.... It's probably an unavoidable thing. Whether or not it's a good thing depends on the quality of people that you have. And I don't know whether ARPA's been lucky or whether there's something built into it that causes good people to be here. I think its self-perpetuating to an extent. A place that has good people can handle the degree of autonomy which ARPA has, which is still enormous.

The power and authority of my position within [my field] is quite significant. I sit here behind a desk and make decisions about millions of dollars a year, without any review boards, or advice or panels, or anything else that I don't specifically, personally, want or request. Now, I have to sell that through ARPA, but I've had really very good success in doing that.... With that amount of money, which would be nothing in physics, you couldn't buy a decent laser ... but in [my field] that has an impact. I have made a significant impact in several areas....

[I]f I were really dumb or dishonest or something that I hope I'm not, it would be too bad. Then you could point at it and say: 'How insane ... obviously someone forgot to put in a review board.' Now that would make everything take a lot longer. It would be a lot less exciting work because you have to please everyone ... or at least satisfy them, and you would knock off a lot of the interesting parts of whatever it is [you're proposing]....

[I]t seems to me there ought to be a place [with ARPA's freedom] ... whether it should be in the Department of Defense I don't know. I tend to think not -- but on the other hand, if it's not buried [could it survive?].... [Moreover this office] is a tiny part of ARPA. Many people are just unaware of its existence. And if it wasn't like that, if it stood out there in the glare ... maybe it couldn't exist. It would be so thoroughly scrutinized and harrassed....

I was talking then about our office specifically, but ARPA as a whole probably has an important place within DOD. The Services certainly aren't going to stick their necks out.... [T]hey attract people who are conservative and cautious and slow and concerned more with bureaucratic process than with substantive research.... It seems to me that you badly need an infusion of a little more life and activity. ARPA sparks things, you know [some personal examples here of pushing the Services to do things].... They [the Services] would be taking a terrible chance to take their money and put it into that kind of basic research. If it didn't work they'd be in trouble; if my stuff doesn't work, nobody really expects it to anyway and nobody notices too much if it doesn't. If nothing worked, Lukasik would have dumped me long ago I suppose. But, you know, some of it works and

> it's all interesting. And if it doesn't work then it's good to know that it doesn't work.... So, it seems to me that it serves an important purpose.... I think in general ARPA's ability to respond quickly and take risks is an important thing and I don't see how this could exist in any other agency. [In the Services, any such budget] would just be sucked away. You would never accomplish anything....
>
> [The Service R&D people and ARPA's Service agents] are from my experience, well, dumb. That's what it comes down to; not necessarily low IQ, but not too much imagination or spark or aggressiveness. They pick out these jobs, they spend their life in them -- what the hell do you expect? They're bureaucrats. That's what they are. They're more concerned with ... the bureaucratic aspects: whether they can get approval, whether it's going to make their office look good, how it's going to affect the way their budget looks to Congress. I don't give a [damn] about that. It has to be attended to ... [but] I want to think up research and have a fine scientist bring my fantasies into reality. That's what's fun.

Thus despite tendencies toward institutional rigidity ARPA apparently retains a spiritual heritage tracing in part to the space era and in part to the Ruina renaissance. It is a heritage that persists in maintaining that ARPA is not routine, but rather concerned about the important, the interesting and the innovative. Given the constraints on the Agency in recent years, the fact that some ARPA personnel still feel oriented toward bringing "fantasies into reality" and toward the "fun" of substantive technical accomplishment is probably remarkable. Lukasik paid tribute to the quality of ARPA's people. Acknowledging that the Agency was theoretically vulnerable to too much cronyism, incest, small in-groups, "shoveling out the money," etc., he said that ARPA could be a gigantic scandal, but it never has succumbed because of its "good people."[11]

This feature also helps to explain ARPA's apparent success in finding and attracting high quality outsiders to serve as consultants, advisors, members of study groups, contractors, etc. And good people have been attracted to ARPA, both to work within it or associate with it, because compared to the Services and others, ARPA lacked vested interests. It tended to call the shots as it saw them, and it was recognized that as part of OSD, ARPA often was close to the sources of power and decision-making in the Pentagon. Its obvious role in DEFENDER, VELA and even AGILE for a time, confirmed its status. ARPA could, more often than the Services, gain access to talented people who would not otherwise take an interest in national security issues.

ARPA's 6.1 research also played a special role in enabling it to press top flight people into service when needed in DOD:[12]

> One of the great strengths [of ARPA's 6.1 research] was that we were in first name, trust-one-another, contact with people throughout the country ... very strong people in any field that had any real [connection] with the Defense Department.... We had access at the end of the telephone to the best wisdom, analyses, advice, criticism in the country. Part of this was that mutual trust that built up ... that we always learned something from somebody coming into the office.

ARPA developed a "flair to interact back and forth" and to "get the most out of people as well as projects" that Sproull, for one, considered one of ARPA's most important attributes.[13] It was still in place, and just as highly valued, when Rechtin took over:[14]

> I thought that ARPA's contact with the technical community was a major asset. That was one that was there long before I got there. I tried to retain [it]. I think it has been retained since. It's a hallmark of ARPA, and that community is what generates the ideas.

There is another side to the people issue. Many observers choose to explain ARPA's troubles in the very late 1960's and afterwards largely in terms of a reduced ability to attract high quality staff. The reasons cited are obvious: unhappiness with Vietnam policy; the particular disenchantment of university people with the Defense Department and a variety of national security policies; the alleged anti-science bias in government symbolized by President Nixon's gradual dismantling of the White House science apparatus; re-emergence of a significant gap in government and industry salaries at the highest grades; increased unemployment, which makes those with a Civil Service appointment less eager to leave and those on the outside more sensitive to retaining their positions in industry or the universities; the attacks on ARPA's existence; the Agency's low-profile posture; diminution in funding flexibility and ability to free lance; a perceived decrease in access to the Secretary or involvement in major policy issues, etc. ARPA still attracts the outstanding individual for specific projects, it is felt, but not across the board. Dr. Ruina, among many others, believes that the quality of people in government generally has "gone way down."[15] ARPA is not immune to these trends and dealing with them is expected to be one of its major challenges for the future.

Filling Service Gaps. There is still a frequently expressed opinion that an ARPA is needed to handle projects of interest to the Secretary which a Service might ignore, to manage projects involving more than one

Service, to insure that alternatives to particular Service programs are actively pursued, and/or to challenge the Services. It is sometimes difficult to know whether this is a reflex, by-rote response or is actually firmly believed. Rechtin and Lukasik routinely talked about working on projects of interest to more than one Service, but because of funding restrictions and their emphasis on transfer, ARPA tends to do less of that now on an exclusive basis and seeks to make its influence felt by participating with the Services on programs of mutual interest. In the case of lasers, Foster provided generous funding to the three Services and ARPA, a reversal of the original 1958-1959 assumption that a Secretary or DDR&E would usually be inclined to avoid multiple efforts. Programs of interest to none of the Services were less likely to be picked up in the ARPA of the early 1970's because the Secretary and DDR&E were no longer making such assignments and ARPA as a matter of policy was tending to avoid initiating, on its own, programs for which there was no clearly visible Service user. Whether this condition is temporary or permanent is impossible to determine.

There seems to be a continuing consensus that ARPA can be very productive in stimulating or challenging the Services to do better R&D, but absent solid support and protection by the Secretary and the DDR&E, "stimulation" and "challenge" can quickly yield a backlash in which ARPA is criticized for interference, wasting funds, creating confusion, or worse. While Foster was sensitive to the latter criticisms, he nevertheless insists that ARPA exists as "a mechanism to instill a new range of scientific and technological potentials" in the Defense Department and that he used it to do things that "the Services wouldn't, couldn't or shouldn't do."[16] He still asserts that ARPA's primary function is to excel in doing advanced research; conversely the Services cannot be expected to excel in that role because they have so many other functions to perform. For him, "science and technology can have very high leverage on military systems and therefore it makes sense to concentrate on the leading edge," and that is ARPA's purpose. [17] The words could have been uttered by Roy Johnson.

Rechtin would underscore this viewpoint by arguing that in times of budget stringency, the Services either do not or cannot protect their budgets for advanced research. The great difficulty one has in weighing this "leading edge" theory is that during the Foster/Rechtin/Lukasik era ARPA seemed to be moving away from the leading edge as often as it approached it. Low profile, quick-transfer oriented, "no screwball ideas," obvious military-relevance agencies are not well suited to the achievement of revolutionary breakthroughs or major developments. Moreover, as Frosch suggests, ARPA has not been especially successful in protecting its own budget for advanced research.[18] A case in point is comparison of the original ARPA role in ballistic missile defense R&D and its 1970's entry into antisubmarine warfare R&D. ARPA's ASW work is much more intimately linked to Service programs than were large parts of DEFENDER. The Agency has not been able to get either a charter to match the open-ended DEFENDER assignment nor a DEFENDER-scale budget. What Frosch calls "laboratory-scale financing"[19] will not suffice, normally, to make major advances. It is well to remember that the DEFENDER charter was virtually unlimited. As Sproull summed it up: "we did pretty well what we wanted," and the program had funding to match.[20]

In other fields as well, ARPA's ability to produce a "critical mass" of support for a given area of work often appears to be the dominant factor behind its success, and without it Service relevance may mean little. Thus one of the most pressing questions for the post-1973 tightly budget-constrained ARPA is whether it retains the ability to reach a threshold level of support that can really "make a difference" in a given technical area. Perhaps under the influence of stricter relevance requirements, and definitely reflecting the pressures of the Vietnam War, the "leading edge" in recent years increasingly has come to mean, in the view of several observers, some type of high technology "gadget" like lasers, NITE GAZELLE or the arctic surface effects vehicle. Indeed to some, ARPA has come close to being an "advanced procurement agency" rather than an advanced research agency, with occasional excursions into 6.3 (advanced development) and 6.4 (engineering development) territory.

Flexibility and Quick Reaction Capabilities. ARPA has always laid claim to being a flexible, quick-reaction agency. Initially, that meant being quick to recognize good ideas and to start them with a minimum of red tape. It did not necessarily mean quick results. Over time this feature of ARPA has been interpreted on occasion to mean "quick to get a result," e.g., the field test of the AR-15 rifle in Vietnam. The subsequent Vietnam ZAP channel work was based, pure and simple, on ARPA's ability to commit funds fast and the DDR&E's power to mandate, directly, that the necessary internal reprogramming be done to free up the funds. Indeed Dr. Foster describes ARPA as "a crisis agency,"[21] but the crisis response sought for Vietnam was considerably different from the Sputnik crisis response that stimulated McElroy to establish ARPA.

Prior to 1968, ARPA tended to think more about technologies than end items. It continued to be motivated, in fantasy if not in fact, by the Roy Johnson mission of serving as the Secretary's personal agency in R&D -- quick, agile and efficient in the task of giving the Secretary an independent "technological audit" in fields of special concern to him. This conception depends vitally on having Secretaries who think in such terms (an issue discussed further below), but accepting that assumption for the moment, this was a rationale for ARPA in the mid-1960's and one which Dr. Sproull, for instance, would claim is valid today:[22]

> One can move fast, can be responsive, one can be an extension of the arm of the Secretary if he wants to make sure that the Army program in something or other is moving as fast as it possibly can, and he is uncomfortable about that, he can be talking with ARPA people and putting some additional money in

> ARPA, he can get kind of a technological audit of that ... which would be more efficient than simply putting more money into the first agency ... which would have a tendency just to keep working at the same ideas. I think it's a very good use of a fraction of the money.

Lukasik's view of the need for an ARPA to avoid "technology perception gaps" was very close to this perspective.

The DDR&E's use of ARPA's quickness in the late 1960's was less to perform an audit for the Secretary than to respond to the enormous pressures on his office for R&D contributions to the Vietnam War. Lukasik uses the phrase "the urgent drives out the important" to describe this period, but the phrase reflects a persistent, built-in dilemma for ARPA.[23] The Agency's virtues as a convenience to the DDR&E simply are not always mutually supportive of other Agency missions. The Congress, for its part, seems to prefer that ARPA function in the relatively large area that falls between an Arecibo project on the one hand and buying hardware for immediate field combat testing on the other. ARPA remains vulnerable to unduly narrow interpretations of its quick-reaction attribute.

"Presidential Issues." The most obvious dividing line between the ARPA Directors concerns feelings about Presidential issues and ARPA's role vis-a-vis the Secretary. These differences are well-illustrated by their reactions to the hypothesis that ARPA has served its purpose, but now no longer is needed, in part because there are no advanced "breakthrough" ideas equal in significance to the missile/space/nuclear energy combination of the late 1950's to work on and/or because the Secretary and the DDR&E can now control Service rivalries and assign them work in full confidence that it will be done. In other words, perhaps events have passed ARPA by.

Surprisingly perhaps, Dr. Killian rejects this notion:[24]

> I now feel that ARPA is a useful agency in the Office of the Secretary of Defense but the DDR&E should be heavily involved in the decisions in regard to its program. I do not think that developments in the military services or in their roles and missions indicate reason to give up ARPA.

Dr. Ruina reacted to the same proposition with the comment: "That sounds not unreasonable."[25] He added the caveat that if a Presidential issue were at hand, he would want an ARPA, but he sees none (i.e., something that might significantly alter the strategic weapons situation) presently on the horizon. Presidential issues in which Service vested interests are involved warrant an ARPA: "[I]n VELA and BMD an ARPA was absolutely essential."[26] Without such issues, an ARPA is questionable. This leaves unsolved the problem of sustaining an ARPA-like capacity "between issues" or attempting to create a new one whenever an appropriate issue arises.

Drs. Sproull and Herzfeld also fall clearly in the Presidential issues camp, but are inclined to believe that there will always be such issues, or something akin to them, facing the Secretary. Herzfeld, for instance, believes that "any technical enterprise over one billion dollars needs a high quality, quick reaction shop" to handle that ten per cent of the problems that the organization's "steady state management" system will not be able to handle.[27] Dr. Heilmeier has also likened ARPA to a corporate R&D activity.* This choice of analogy is somewhat similar to the McElroy-Johnson "blue sky" unit.

Herzfeld's agency, however, is presumed to have very close links to the top, i.e., in DOD, a close "coupling" to the Secretary and his problems as the dominant customer. VELA and DEFENDER are his models. For these issues:[28]

> ... it was a good thing for the OSD, on program[s] this important, to have its own capabilities. And I have come to be convinced that's the right answer. So much so that I think any very large organization really ought to have an ARPA in the office of the president. Because, if the stakes are high, it [the work] has got to be right, and it has to move as rapidly as possible.

Sproull's "technological audit" function is based on the notion that it makes sense for the Secretary and his DDR&E to devote some two to five per cent of the Department's RDT&E funds to that purpose, and that having an ARPA "is an effective and efficient way of doing it."[29]

The harsh reality of the Rechtin-Lukasik period was, as previously discussed, that the Secretary and his peers had largely lost interest in ARPA, apparently did not see it as especially useful for resolving that "ten per cent of difficult problems," and did not accept the need for an ARPA-directed technological audit on their behalf. One can speculate that during the McNamara era the growing conviction that new technologies were driving the arms race helped to create negative feelings about the advanced research agency. For instance:[30]

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* Heilmeier's ideal corporate R&D agency, and ARPA, are intended to serve five functions: (1) filling gaps, by covering high priority problems that cross Service lines, (2) doing unique or unconventional jobs, (3) tackling "the revolutionary rather than the evolutionary," (4) undertaking "high risk alternatives which may run counter to the conventional way of doing business," and (5) behaving as an agency with no vested interest in the status quo. (House Committee on Armed Services, Military Posture, Hearings, 94th Cong., 1st Sess., "Research and Development Subcommittee Title II, H.R. 6674," Part 4, March 24, 1975, 4903-4904.)

> Secretary McNamara and other senior civilian policymakers in the period after 1960 appeared to feel that any radical new innovation in weapons systems on the part of the U. S. defense establishment might destabilize what they hoped would be a relatively static kind of symmetry in the major weaponry maintained by the world's most militarily formidable nations. In this sense, then, there appeared to be conscious decision after 1960 not to allow the armed forces to push ahead on innovative ideas conceivably leading to major new departures in militarily useful technology.

ARPA, in its headiest moments, liked to think that it was chartered to do just that, i.e., to "push ahead." One could even argue that York and Brown, in concluding that there were many fewer exciting technical ideas with breakthrough potential to work on, were permitting policy desires to color their professional judgments. Such speculation is pointless, however, because the more "hard line" Nixon Administrations seemed no more interested in ARPA than the Johnson Administration. They were intent on "tilting" back toward the Services within DOD. Secretaries no longer assigned work to ARPA. Moreover Rechtin confirmed the paucity of good scientific ideas during his tenure. Thus ARPA Directors after 1967 could not operate on the assumption that they were in fact the Secretary's agent.

ARPA staff during at least the first ten years of the Agency's existence identified very closely with the Office of the Secretary. This OSD connection was a matter of great pride with most of them. Their OSD identity, if anything, transcended their ARPA identity in importance. For an independent, flexible sort of agency, ARPA was markedly free of unauthorized flights in directions purely of its own choosing, in the post-Roy Johnson period.* The various Secretaries of Defense and their key associates probably never realized the depth of this type of OSD loyalty and certainly failed to exploit it as fully as they might have. Part of the tremendous readjustment required when the "Presidential issues" programs were transferred or closed out was a function of the feeling of loss by ARPA staff of close connection with the Secretary and his concerns, which they had assumed more or less as a birthright.

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* For instance, Project AGILE was created in part because Godel believed DOD needed to grapple with the insurgency problem, knew the Services would not, and felt that the Secretary would be forced by events to take the lead. Skeptical ARPA Directors tolerated AGILE because they believed that "somebody" had to do it and, at least initially, the signals from the Secretary's office were that it was important to him and to the President.

The challenge to the ARPA of the future may be in defining and maintaining a non-Presidential issues role that is sufficiently unique and valuable to warrant retaining the organization. This problem appears to be a real one:[31]

> [W]e now have an ARPA ... with some 40 projects. All of them quite good ... that is, the technical quality is very good. The transfer problem is licked; it works very well into the Services. In fact, on some projects you can't tell whether it's an ARPA project or a Service project, and that's good for many of these things.... However, it does make it a little difficult ... to figure out what's going on, because there are no central themes of large scale at the present time There are 40 of them, each of them [in the] $5 to $10 million class.... But you can't say what central, national problem is this collection working on ... that isn't there.

New leadership personalities, of course, could attempt to change this situation overnight. Nothing legal has been done to foreclose re-creation of ARPA's role in DEFENDER or VELA. Dr. Rechtin, however, believes that it would be extremely difficult to do:[32]

> If ARPA had tried to keep itself in the national spotlight, perhaps there would have been national problems that ARPA would have been handed [by now]. Who knows? I don't....
>
> I'm not sure it's practical [to have ARPA work on national-level problems]. The reason is, how the hell are you going to get the Congress to OK it? They've already insisted that ARPA's budget be broken down in sufficient levels that you can follow all these projects at sort of the $5-$10 million class. And if somebody came in tomorrow morning ... and said 'we want to aggregate a few of these in the interests of better management' ... we'd get shot right out of the saddle.*

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* Ironically, ARPA may be involved in a current Presidential issue, namely, the role and implications of the strategic cruise missile. According to one report, "the present incarnation" of the cruise missile uses a turbofan engine concept based on one developed by ARPA in the late 1960's for a "jet belt." This was the AGILE work aimed at using jet propulsion packages to lift individual soldiers. (Deborah Shapley, "Cruise Missiles: Air Force, Navy Weapon Poses New Arms Issues," Science, February 7, 1975, 416-418.)

Nonetheless it might be argued that a return to larger-scale, "Presidential issue" problems could be worth the risk. This is probably a debate worth having, a quasi-philosophic thinking through within OSD of what an institution like ARPA might best be used for, over time. We will return to this point below.

<u>"Avoiding Technological Surprise."</u> One mission claimed by some of the ARPA Directors in both the Presidential issues and non-Presidential issues camps is that of guarding against technological surprise. ARPA's "anti-surprise" mission has always been a bit vague, frequently misinterpreted, but often repeated because the rhetoric has a resounding ring, as does the companion phrase frequently used by Dr. Foster, "achieving technological superiority." Roy Johnson clearly started out with the task of investigating outer space technology (including the ballistic missile defense problem) on an accelerated basis in order to guard against other Soviet surprises in <u>that</u> medium. Even the propellant chemistry and materials sciences program assignments were justified and discussed in terms of their relevance to missile and space systems. Furthermore ARPA was consistently described explicitly as a program-oriented or project-oriented agency. The Services zealously monitored ARPA for several years to insure that it did not undertake a whit of work without formal assignment, in part because of the fear that ARPA might acquire a monopoly over important weapons R&D and compromise their respective futures. Thus ARPA was in no position to be a general purpose "anti-surprise" agency. General Betts has made it crystal clear he believed that the Agency had no such mission when he directed it (see Chapter IV). Nor apparently did Dr. York, the DDR&E at that time. Asked if ARPA had caused him any particular disappointments, measured against his expectations for the Agency, Dr. York replied:[33]

> No, not really. I don't think so. Because I didn't really expect any of the problems to actually be solved. In other words, the fact that ARPA didn't come through with any breakthroughs was not a disappointment.

Dr. Sproull, however, was and is a very keen supporter of an ARPA "anti-surprise" mission:[34]

> I regarded that [guarding against technological surprise] as the heart of our mission, as a matter of fact, I didn't regard those 'buzz words' as pejorative at all. They are 'buzz words,' no question about that; they were ... in those days. But the fact is that I regarded it as one, if not <u>the</u> principal mission of the Agency: to make sure that there wasn't something that had been turned down by the Services as too risky, or impossible because of the way the Defense Department is

> divided up into Services, something that fell in the cracks, that the Soviets were going to come up with, or somebody else.... That ARPA would be the people that the Secretary and the President would have the right to say 'well the reason I have ARPA is just to make sure that we don't get that kind of shock.'

But note the assumption of Presidential and Secretarial involvement and concern. Moreover there are additional qualifications crucial to Sproull's conception of ARPA in this role:[35]

> The budgets that we had in those days -- which were $300 million, give or take a little -- were a hell of a lot of money, if you played your cards right.... The type of surprise that we are trying to protect against was the Soviets building a laser before we even knew that a laser existed. And if we had good enough contacts with the academic community and if we put money out to goose the strong people in the Service laboratories and in academic laboratories, we couldn't guaranty that, but we could work as hard as we knew how on it and we could have had a fair chance of success in protecting against [a] Soviet success ... that would be a definite change in the balance of power, from a scientific invention. We took that extremely seriously. It's true that a lot of our money was poured into continuing programs and wasn't all that flexible. On the other hand, we kept some 6.1 money in almost every project, some way or another, and we did a lot of bootlegging of things in DEFENDER, for example ... you can't put your money out to ward off technological surprise and not have mistake after mistake after mistake.

ARPA then played an anti-surprise role largely within the confines of very broad program assignments like DEFENDER and within a very large total Agency budget (a third larger than present day budgets in current dollars and much larger than that in constant dollars). The large programs and large budgets permitted 6.1-type "gambling" and also provided sufficient "background noise" to absorb mistakes. 6.1 work in DEFENDER, for instance, was easy to justify as relevant simply by defining it as related to missile defense R&D. ARPA was both confident enough and big enough in dollar terms in 1961-1967 to do high risk projects and not worry unduly if they failed.

Latter-day ARPA's appear to have lost much of that flexibility. Some program titles such as Strategic Technology and Tactical Technology are even broader than Ballistic Missile Defense or Nuclear Test Detection;

however, the assignment within them of bite size program elements, very discrete projects with reasonably precise relevance or transfer rationales, and relatively low budgets, makes carrying out a true anti-surprise mission somewhat unlikely. There is no margin for "glorious mistakes" any longer; they are no longer as readily hidden or absorbed, although intelligence-related projects sometimes offer scope and justification for doing so.

Some of our respondents consider discussion of whether ARPA is capable of playing an anti-surprise role irrelevant because the concept itself is faulty. Dr. Ruina, for instance, believes it is foolish:[36]

> I never believed in a surprise.... The whole idea of surprise is somebody is going to open the door and out comes an operational system. It's just madness. There's no history that that ever happened.... What you're surprised by is, sometimes, an experiment that they do.... But the implications are that there's a surprise, that a door opens up, and there is an operational capability that you couldn't have. That never happens. And it's just fantasy. Why do they keep this tremendous air defense structure? We are closing down ours; why are they keeping their's alive? And it's costing [them] billions a year.... That's the nature of surprise. But a technological surprise changing the strategic balance is just madness. You know, I don't think I ever felt that way.

Dr. Rechtin, it will be recalled, sought to follow Foster's instructions to return to the fundamentals of the early ARPA, which they tended to define as "anti-surprise" and "quick-reaction:"[37]

> So I went back to the foundations of ARPA, essentially, and said to avoid technological surprise [is] to do the things we weren't sure of what the end military mission would be; you just knew that there would be a military mission of value. But you couldn't tell us where the best value would show up. You almost never can. You can't even tell that in a weapon system, much less on something in research.

As noted, this was extremely hard to do in the context of insisting on relevance and rapid transfer. Looking back on the experience, Rechtin adopts a much more Ruina-like posture:[38]

> You can't do anything fast enough in this business, that the other side can't compensate for before it gets disastrous. In other words you can't come up with an overwhelming operational advantage in any short time. The systems are too big to do this. Now, you can come up with a technological surprise. You can come up with a Sputnik, or you can come up with a new ASW technique. But you can't make it effective for some years. Three years minimum. Ten years for some of these things. And in that time there's a chance for a counter move, to keep it from being a disaster.

Lukasik too, as noted elsewhere, said that given ARPA's circumstances he found himself believing in the anti-surprise mission less and less: "I found that that was an idea that didn't wear very well."[39]

Foster, alone among the many people interviewed for this study, remains a strong, essentially unconditional "anti-surprise" enthusiast. He observes that at the time of Sputnik the U. S. was putting two or three times as much effort into science and technology as the USSR. Now he estimates that they are ahead of the U. S. on this measure and that perhaps 70-80 per cent of Soviet R&D resources is devoted to military capabilities; hence it seems reasonable to him to expect a crisis soon and that it will be necessary to reinvigorate or reinvent an ARPA: "Today, much more than 1958, you need an ARPA."[40] While a minority view in our sample, it is not to be dismissed lightly. A Soviet demonstration of, say, some strange new orbiting offensive weapon, could result in a reaction not unlike Sputnik and a modest witchhunt to determine why the U. S. was caught so unprepared.

Basic Research Role. Few things have consistently polarized feelings about ARPA, from 1958 to the present, as clearly as the debate over doing basic and applied research (6.1). Betts, Ruina, Sproull, and Herzfeld for instance, are very keen on ARPA 6.1. Dr. Killian remains adamant that DOD has an obligation to support basic research and that an agency like ARPA is a good one to do it.[41] Ruina today assesses the institutional value of ARPA largely in terms of its performance in the 6.1 area, in part because it appears that "high quality research" and 6.1 tend to be synonymous in his thinking. Asked to assess ARPA's level of accomplishment over its lifetime, he developed the following portrait:[42]

> Compared to what the rest of the Services did, my guess is they [ARPA] did better. Compared to what you really can do with that kind of money, I'd probably given them a C minus. [ARPA] should have been pushing more promising technologies and better people all the way." I think the Arecibo thing

> could have been done ten times over in different fields as far as the basic research end.

Rechtin and Foster sought to remove ARPA from what they felt was an over-concern with 6.1. Lukasik moderated that tendency, but did not reverse it, seeking to justify some basic research on the ground that it was the best source of "breakthroughs," but retaining pride of place for 6.2 work because it would produce more "successes." There are vast conceptual and semantic problems in this subject beyond the scope of this paper. Suffice it to say that 6.1 is one man's definition of truly "advanced research," but another's idea of chasing rainbows -- both may be equally dedicated to the search for revolutionary technology and using ARPA to support it.

Oddly enough, as ARPA has aged, the idea has been broached on several occasions to centralize <u>all</u> DOD 6.1 R&D in the Agency.* ARPA itself has never been the source of this suggestion and only one of its past Directors would be inclined to support it. Indeed ARPA has tended to be embarrassed by such a notion because the Services believed that ARPA must be promoting it.

General Betts has concluded that the idea has some appeal:[43]

> It could be done.... [T]raditionally it hasn't been, [but] I guess if I were reorganizing the whole operation right now I'd be just as happy to see a 6.1 effort managed centrally. [Provided] the Services are represented by people who know the Service problems in whatever staff of DDR&E managed that central effort.... I would do it in ARPA.

The remainder of his colleagues disagree. Herzfeld believes the Services must be kept in direct contact with scientists on the outside or they will lose all receptivity to new ideas, i.e., it is important to keep some 6.1 in each Service program.[44] Sproull did not think the idea was sensible. Foster was not a proponent of expanding ARPA's limited 6.1 program, much less an advocate of assigning it the dominant 6.1 role in DOD. Like Herzfeld, he worried that consolidating all 6.1 in one place "would cut the guts right out of the Services, and polarize and alienate them."[45] He also felt, as do most of the ARPA Directors, that coupling the results of

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* For instance, at the time Dr. Sproull took over ARPA, the National Academy of Sciences (especially its President, Dr. F. Seitz) urged that ARPA seek to become the czar of DOD 6.1. The GAO has called for central management of DOD 6.1 based on the conclusion that the Services were mismanaging such work, and the Laird/Packard Blue Ribbon Panel on DOD reorganization made a similar recommendation, designating ARPA for that role.

the hundreds of millions of dollars of DOD 6.1 work done annually to the engineers, operators, etc., in the Services was too big a job for one agency. It would require ARPA to devote an immense amount of its effort to managing an empire of largely routine work. "ARPA has to do mostly 6.2, it really does. It should be aware of 6.1, but do 6.2 mostly."[46] Most of the ARPA Directors accept Foster's reasoning for rejecting the idea of doing all DOD 6.1 research. There are still wide differences of opinion over how much it should do.

Lukasik had to deal directly with the Blue Ribbon Panel Report recommendation and opposed it. He explained his position as follows:[47]

> [Congressional committees asked about the desirability of ARPA centralizing control over all 6.1.] It was a typical case of whipsawing because what they wanted me to do was say 'that was a fine idea and ARPA would be a great place,' and I was volunteering for the job.... [But] I would never bite.... [T]he amount of money we are talking about is some $250 million, which was about equal to or slightly larger than the size of ARPA. And you know that you don't move $200 million in the Defense Department or any agency without a great deal of strong [opposition] ... the Services aren't going to lose that kind of change.... So, I knew that I would be dead bureaucratically if I ever did....
>
> Is [central management] a good idea? I do think yes. Should it be in ARPA? You could not drop $200 or so million into ARPA -- double its size -- and keep ARPA the way it is. We would literally 'kill the goose that's laying the golden egg'.... So you would have destroyed ARPA by doubling it, you would have gotten inefficiencies in ARPA. Congress would not have given ARPA the billets to do it any way. The Services would have killed ARPA, if ARPA had tried to make that kind of a grab. [F]urthermore, it would have badly shifted the balance because now instead of having ARPA 20 per cent 6.1, which meant that ARPA was driven by the 6.2er's -- [in other words] was driven by the tactical and strategic technology office, and the VELA office, the guys [who] were kind of 'in the real world' -- now you would have had basically, you know, a $200-$300 million 6.1 with kind of like a $100 million 6.2. It would have become ARPA's NSF. It would have been a great science operation all right. And then you would have had those poor 6.2er's who ... are critical to communicating with the Services, you

> would have lost [them] in the noise.... Furthermore, if Congress is going to do it, it's because they believe there are some inefficiencies in the Services. Now, the way Congress works, is, if they see a $250 million pot of money in the Services and they think it's inefficient and they decide it's kind of one-third wasted.... They [will] take the third off for inefficiency off the top and keep that and pass on to us the $180 [million]. Expect us to do as much with $180 as was being done with $250 ... and leave us to sort out all the guys who were sopping up that remaining third of the money who weren't getting it. So we would have gotten, you know, political and bureaucratic hassles up the gazoo and so.... [I]t's an idea that's better in principle than it is in practice.

There seems to be little or no likelihood that ARPA will be designated as central manager for DOD 6.1 research. It is not clear just how much of a 6.1 role it should play in the future. Granted the NSF is more adequately funded, will it or other agencies create something like the apparent elite corps of materials sciences university centers, an Arecibo facility, or the computer sciences advances attributed to ARPA?

Consider the following remark:[48]

> ARPA is considered throughout the field as being the main supporter and perhaps the most important force in the course of U. S. and probably world history in the computer.... Although the rest of the world has probably heard more of the ARPANET than [it has about 6.1] computer work, [the latter] was clearly one of the main reasons why the U. S. became dominant in the computer field, because it had these programs at the various universities that were developing people and concepts and ideas, and time-sharing and various other things. I think it's had a tremendous impact, certainly in the early days when Lick was running it ... the country would never have grown in the computer field the way it did if it hadn't been for ARPA.

While ARPA stresses the military value of developments like time-sharing systems, MULTICS, ARPANET, etc., their greatest importance to the country may lie in non-defense uses. Moreover, ARPA probably would not have had ARPANET's to crow about if it had not moved into generous support of the then-risky 6.1 work which made them possible. In the early 1970's, one is hard pressed to envision ARPA taking that sort of plunge in an entirely new area. One senses from the myriad explanations given by our respondents that the immediate reasons why ARPA reduced this role are quite clear, but that serious post-crisis evaluation of whether DOD and/or ARPA should, under some set of conditions, resume similar activity has not been attempted.

Deciding How to Use An ARPA

One of the strongest impressions an observer gains from a brief period of concentration on ARPA's history is the remarkably small amount of time which has been devoted by senior policy-makers, e.g., the Secretary, Deputy Secretary, DDR&E, and the ARPA Directors, to considering how best to use this sort of institution. We are not referring to the annual budget cycle and the inevitable discussion of what is going to be done in the next 6-12 months. Rather the issue concerns determining what the most significant DOD problems are and communicating that in such a fashion that it is relatively clear to an ARPA just what problems it should attempt to apply its R&D resources against.

Conceivably one might conclude after undertaking such an exercise that the Department did not need an ARPA, thereby justifying elimination or a deliberately-chosen program designed to preserve and strengthen an ARPA capability for future periods when it was anticipated such an agency would be needed. On the other hand, the conclusion might be a far more direct articulation of priority defense issues, as the Secretary sees them, to guide the scientists and technologists in devising an ARPA program. This assumes, of course, the original ARPA connection to the special concerns of the Secretary. The Rechtin/Lukasik experience indicates that this special connection was severed and in its place ARPA sought to develop problems for attention on the basis of closer Service, JCS and unified command relationships. This indeed may be the appropriate ARPA role, but as the period under review in this study closes, it is not clear from the record whether this occurred as a matter of conscious choice by senior decision-makers or by dint of special circumstance and/or default. There seems, however, to be a strong circumstantial case for special circumstance and default.

Apparently Dr. Foster mounted a campaign to identify important RDT&E issues meriting treatment by DOD, including ARPA. He used the Ramo Subcommittee of the Defense Science Board, the science advisory committees attached to the Services and other agencies, former associates in the DOD/AEC laboratory system, etc., and tried to "diffuse down" ideas that emerged into DOD. He also made a crucial statement about the practicality of the procedure by which problems are identified:[49]

> There is a hell of a lot of structure for this, and it works, but it's limited by the number of able people and how long they will work, and by the willingness of the Secretary of Defense, Deputy Secretary of Defense and the DDR&E to work [it].

Our research suggests that too often this mechanism has not "worked."

The lack of serious discussion at high levels of what an ARPA should do and how to use it applies not only to identification of appropriate DOD problems, but related policy questions such as the Defense Department's and ARPA's future role in 6.1; the possible use of ARPA in 6.3 or 6.4, i.e., should ARPA's informal entry into work of this type via the Vietnam emergency be formalized under certain conditions; should a Presidential issues focus be investigated again or firmly rejected, etc. Dr. Herzfeld confirms the general absence of that sort of policy debate and makes the highly relevant observation that "every DDR&E [in the period under study] has inhibited discussion of ARPA's future." It is as if ARPA over the years was doomed to fulfill the stereotype of the temporary, stand-by, quick-reaction agency, available to perform "conveniences." The Agency probably deserves better, bearing in mind that one of the costs of a more explicit consideration of its long-term role and program could be termination.

Curiously the absence of institutional discussion of ARPA at high levels has been mirrored in the Agency itself, with the possible exception of late 1958-1959 when Roy Johnson's Policy and Planning Division developed the controversial long-range plan for outer space research and development. Other than that exercise ARPA itself has done remarkably little long-range thinking or advance planning as to what it should be doing. The phrase "advance planning" is somewhat inexact: we do not mean day-to-day planning, planning how to conduct an approved program, annual budget planning, routine for-form's-sake extrapolation of current program trends for the next five years, etc. Above all, use of the phrase does not connote erecting some new bureaucratic obstruction that in all likelihood would serve to stifle the flow of ideas from program directors, contractors, consultants, etc., or compromise those elements of the ARPA style most unique to it, e.g., providing support to controversial ideas emerging from unexpected sources, often on an accelerated basis. What "advance planning" is intended to suggest here is an issue touched on by virtually all our key respondents, namely, thinking beyond immediate program obligations to consider what ARPA should be preparing to do or cease doing, a couple of years or more hence.

Roy Johnson's excursion into these waters failed. The billion dollar annual estimates for a long-range space exploration program, while fair, were considered absurd at the time. The shock was so severe that both ARPA and "forward planning" were discredited. Johnson's Policy and Planning Division tended to concentrate on space policy issues and setting up programs and offices for the raft of new assignments that were made in late 1959 and 1960-61. The "planning" function withered rapidly and the Policy and Planning Division disappeared altogether under Ruina.

Dr. Ruina essentially did his own planning, more or less on a one-to-one basis with the DDR&E. He did not believe adequate planning could be done by a group of non-scientists nor did he think strong technical people would devote themselves exclusively to a planning function. The Ruina solution was to seek ideas from good people, namely, his own and outsiders such as PSAC:[50]

> Get better people. Nothing beats better people, who are also connected with and listen to and have a kind of peer relationship with better people.

Sproull fell squarely in the Ruina mold. He tended to use his program directors as a de facto planning group, notably Rabinowitz, Frosch and Herzfeld. He never felt the need for a separate central planning staff and indeed considered that one would be "redundant, possibly even embarrassing, if they came up with some report I didn't want to do anything with." [51] Herzfeld's "number one job" for Sproull precisely was to look at problems from the perspective of the Secretary, e.g., "what is it that is spoiling [the Secretary's] breakfast this morning?" According to Sproull, Dr. Herzfeld had a "marvelous capacity" for planning things in the context of the Secretary's concerns. Reflecting the ARPA tendency to "internalize" management functions, Herzfeld was ARPA's planning staff and was able to free people from DEFENDER on an ad hoc basis to explore new ideas in a moment's notice. By reaching out to the staff, JASON, visiting contractors, IDA, etc., Sproull felt that ARPA could adequately cover future planning, even in program areas not assigned to ARPA. It was an informal approach and he agrees that it conceivably might overlook some totally different area of technology where ARPA did not have the right people, but, "if so, I don't think a planning staff would have saved it [ARPA] from that."[52]

Lukasik's conception was much like Sproull's. He doubted the wisdom of having a planning group, particularly one that might develop momentum for ideas of its own at odds with his own. Accordingly his Technology Assessments office was kept very low key and used primarily to test and develop his ideas. He also drew on outside sources such as RAND and JASON. Basically, Lukasik, like Ruina and Rechtin, did his own planning.

The vast majority of Directors, then, preferred to institutionalize planning in themselves or in key individuals in the Agency engaged for the most part in managing substantive, ongoing programs. Most of the Directors averaged about two years in office and a very good case can be made that future planning could hardly be expected to be top priority in their eyes. Moreover the early Directors were part of an era during which it was presumed that, normally, assignments would flow <u>to</u> ARPA, from the White House, the Secretary or the DDR&E. The special connection with higher authority was taken for granted. It was noted previously that the Directors also tended to feel reticent, as relative "short-timers," about committing their successors in advance. Betts, Ruina, and Sproull clearly saw themselves as transients, and Herzfeld and Rechtin probably did too. Lukasik alone had a long tenure, but he devoted his energies more to internal restructuring and adjustments in current Agency relationships than to long-term thinking about the future.

Two of the past Directors take exception to the position of the majority, although both handled this issue "on the job" much as the others did. General Betts believes that ARPA has paid a significant price for its relative lack of attention to consideration of the future:[53]

> I think that's the fundamental problem that ARPA had all along.... It was a continuing problem for the Director of ARPA. I don't remember being terribly frustrated by that problem when I was there, but I was only there a year and I guess I never really got to the point where I was worried about what the next program was that we [ARPA] should be pursuing.

Dr. Herzfeld similarly believes that this issue has been "handled badly" in ARPA. He, like all ARPA Directors, references the constant time pressure facing ARPA's leadership. A Director has to make a special effort to push himself and the organization hard, if there is to be any looking ahead. He also used organizations such RAND and IDA as substitutes, but outsiders, no matter how able and experienced, tend to lack the feel or touch required to sense how best to make a particular agency relate properly to the dynamics of the highest level authorities and issues within a large department. As a practical matter, think pieces prepared by outsiders never proved to be influential.

Herzfeld believes that ARPA needs a policy and planning-type unit. He did not have one when he was Director, accepting the rationale that positions could not be spared. If he were to "do it again," he would restructure the organization to include such a unit, with three to five people and a substantial budget, and endow it with influence within the Agency.[54]

Resolution of this question is not a function of this study. The fact that serious considerations of ARPA's future has so rarely been addressed (in other than the "survival" crunches that occurred during the late Johnson, early Betts, late Herzfeld, Franken, Rechtin, and early Lukasik periods) remains one of the most intriguing aspects of the Agency's history.

Evaluating What the Agency Has Done. ARPA planning in the more restricted, conventional sense of considering whether to discontinue, expand or modify existing programs and projects is an issue that surfaces in virtually every phase of the Agency's lifetime. Indeed the greatest self-criticism that emerges from ARPA staff at levels below that of the Director and Deputy Director (but including some of them) is that ARPA has often been very efficient at spending money, but weak at knowing in detail what it produced. Reference is made to volumes of unread research reports and lack of quality control. With a small staff, it is clear that ARPA professionals cannot read every paper that their millions of dollars buy. The ARPA agent is supposed to do so, and may, but agent performance is a mixed bag.

Dr. Ruina took the position that significant findings always filtered through, were recognized as such and were promptly exploited, whereas "those things that weren't read, we knew weren't too important."[55] But he recalled that there were no formal evaluation procedures and considered this problem inherent in the short tours of Directors. Few Directors ever saw anything that they started through to completion. The same was true of many program managers, at least in the 1960's. There was plenty of opportunity for unevaluated work to slip through.*

This lack of a formal evaluation system puts a premium on having very high quality staff: to do adequate informal or formal evaluations, weed out marginal or poor work and prevent continued funding of those who do such work. ARPA has had some tendency to overlook work of marginal quality and to continue funding the group in question in hopes that it will do better later, or because it is doing well in some other unrelated ARPA program, or because of toleration (sometimes uncritical) of "failure" as a price of doing R&D, or because the program manager is under pressure to reduce his unobligated balance or else lose the money (and the easiest way to do that is to add funds to an existing contract). For all its success in being flexible, locating new talent to support, and transferring programs, ARPA has supported many ideas, individuals and groups for long periods of time. Today's generation of program officers sometimes do not realize that they are supporting people or ideas that date back to the late 1950's or early 1960's. The following view expressed by a program manager in the late 1960's is typical of remarks made by staff who served in almost all of ARPA's phases:[56]

> When I arrived, the [deleted] part of the program was already established, and the contracts in it had their own sets of relationships, and it's hard to turn people around. Dr. [deleted] had a consumer for some of his material [in another DOD office] and he would relate to them and was impossible to reorient. Hence this part of the program was out of control because of the powerful intellectual personalities involved. While I had a tendency to want to cut people off, I realized that

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* Perhaps the outstanding example of ARPA casualness in this regard is a crash effort undertaken in the early 1970's to evaluate all the transferred DEFENDER programs retrospectively, in response to concerns about a Congressional inquiry. The over-$1 billion spent on DEFENDER was categorized and assessed as to percentage of funds "well-spent" on various projects, in a crash two-day period, using a combined internal staff and contractor effort. The evaluation was essentially intuitive, as there was no file of structured program assessments available for use.

> it was easier just to fund new things and leave the old alone. I didn't want to make waves because I had to go back to the [relevant university/industry environment where research of this type was done]. All of this worked all right during periods of adequate funding, but when the pie shrunk the established old people got a larger and larger share. It is an unfortunate reality that people have just continued to be funded until they got in trouble. It's a built-in problem.

As these remarks suggest, some contractors simply "outlast" their ARPA monitors and manage to keep things going in a relatively unstructured way because of the inevitable uncertainties and critical time lapses caused by rapid personnel turnover and other bureaucratic pressures.

The Behavioral Sciences program provides an example, by no means unique, of the linkage between inadequate evaluation procedures and future planning. One program manager in that office, regarded as innovative by his peers, felt very handicapped by the lack of an adequate in-house monitoring capability. His Service agents did a routine job at best, meaning that there actually was very little feedback on research quality from them. When the program had been started, long before his arrival, the idea was to establish centers of excellence or "pockets" of excellence, gave them two to five years to perform and then: (1) evaluate the significance of the work, (2) determine whether there were productive potential interrelations, (3) separate the sheep from the goats, and (4) reformulate or reshape the program. The office directors who had this focus in mind, however, were twice or thrice removed by the time such an evaluation should have been undertaken. Their successors' attention was devoted elsewhere, reflecting perhaps the tone of the remarks in the quotation above, namely, it is easier (and more fun) to start new things than to evaluate or undo the old. At the broader level, there never seemed to be time to do an overall evaluation of behavioral sciences results, to consider the value of the "centers," etc., and reconstruct new directions for the future. Of course, planning for the Behavioral Sciences program rapidly became subject to serious distortion from the bitter political battles over defense relevance and the program's keynote, of necessity, became "what can be saved" and what types of work are "safe" politically, rather than what might we wish to drop, modify or expand based on technical results exclusively. The point, however, is that historically ARPA has been relatively weak at dropping older work and strong in starting new work, in large part because the office directors give priority to the latter activity.

Dr. Sproull reacts hotly to criticism of inadequate evaluation. He believes that there was sufficient evaluation during his tenure, without over-management. He deeply believed that in the mid-1960's period that he knew well -- when so many ARPA successes materialized -- ARPA project and program managers as a rule knew far more about the substance of the work they were supporting, and about the substance of work in their fields generally, than their counterparts in any other federal agency. Indeed it was primarily because of that characteristic that he regarded ARPA as strong and unique.[57]

> ARPA had that strength ... and I hope to hell it had as much of that when I left as it did when I arrived. But that's for somebody else to decide. Anyway, there is no question but what it was a very strong and unusual agency -- the word 'unique' is overused -- but I think it truly was unique.

An ARPA could be reduced to an ordinary, stale bureaucratic agency if it was forced to install detailed evaluation and planning systems. Indeed some critics have said as much about ARPA in its later years as layers of paperwork have been added, e.g., by the DOD Planning, Programming and Budgeting System (PPBS), increased Congressional demands for budgetary detail, Mansfield Amendment requirements, and the Rechtin/Lukasik emphasis on recording and justifying relevance, transfer, etc.* Be that as it may, by the end of the period under review, Dr. Lukasik felt that ARPA had not yet mastered the art of "concluding" its programs, that is more or less formally evaluating and recording what happened. GAO has also criticized ARPA for failing to document the transfer of ARPA projects to the Services and determining their success or failure after transfer exercises, paperwork which probably would not contribute to a more effective ARPA in the slightest. But a more rigorous review of the technical output of programs probably would. To the extent that relevance and transfer, along with smaller budgets, do make it easier to track work and to impose the discipline required for adequate evaluation, this problem may be on the way to resolution. The point, however, is that ARPA professionals strongly predisposed to the ARPA idea are inclined to mention inadequate technical evaluation, leading to wasteful support of contractors, as one of the most vexing internal ARPA management deficiencies.

Presenting ARPA's Record

Intensive review of ARPA's lifetime reveals that the Agency has rather consistently downplayed what it does. Given all the concern about "why ARPA?"

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* We have not addressed the advent of PPBS during the McNamara regime. Management and technical people alike in ARPA found it to be a worthless numbers game. At best it was a scheme for rationalizing R&D decisions after the fact rather than contributing to the decision-making. At worst it inculcated a habit of lying or faking because normally it was impossible to predict results from research and exploratory development programs, and how they were going to be used, for five years into the future. The exercise was regarded as foolish; the added workload on a small agency like ARPA was consequential.

questioning, it is remarkable that so little has been done to make clear to its critics and potential supporters what it has accomplished. We are not speaking here of crass public relations, the glossy "P.R." put out by information office flaks; indeed, ARPA has no such office. The issue is whether ARPA has given an adequate accounting of itself to those in authority and the record suggests that it has not. Consequently when difficulties arise, e.g., the AGILE problems with the Secretary, Deputy Secretary, Congress, etc., there often is an inadequate background of known successes against which to weigh them.

In the Roy Johnson period, ARPA was hardly a wallflower when it came to publicity and visibility. The Services bitterly resented ARPA getting credit for space projects and they constantly tried to publicize their own involvement. As discussed in the early chapters of this report, ARPA was under Presidential order to insure that the Services did not plaster their logos, literally and figuratively, on the space projects. This non-technical responsibility greatly compounded ARPA's difficulties with the Services. When the Johnson era ended and York sentenced ARPA to what then seemed to be oblivion, this situation changed dramatically: "After Roy, the matter of ARPA claiming credit for anything became a curse word."[58] The "low key" ARPA from a public visibility standpoint became almost an article of faith for the Agency from then on.

As noted previously, ARPA rarely sought to make clear who the sources of its early assignments were. Space, ballistic missile defense, materials research, propellant chemistry, and nuclear test detection all traced back to explicit White House requests or endorsements. ARPA said little or nothing about that legacy, except in the broadest generalizations. Roy Johnson's disdain for the Killian group and faith in his own standing with the Secretary may explain his failure to do so. But long after Johnson left, ARPA consistently failed to document for the succession of Senators, Congressmen, Secretaries and Deputy Secretaries of Defense, Budget Bureau Directors, etc., that the work it was doing was deemed important at the White House, or in some instances, to the Secretary, i.e., that the work had a claim to national importance. The DDR&E's, more or less in line with their low key acknowledgment of ARPA, likewise had relatively little to say about it, what it was doing, or how significant its assignments may have been. They almost never volunteered to respond to "why ARPA?" questions, although logically the "why" of ARPA's existence and the structure of its assigned workload would properly have been handled at that level.*

General Betts recognized that York very much wanted to move ARPA out of the spotlight in order to reduce USAF-NASA-ARPA bickering over space. Betts was low key in temperament by nature and preferred to deal with the Agency's adjustment problems in as sheltered an environment as possible. Ruina and Sproull were not noted for horn-tooting. Ruina considers this

* This changed for a time when Dr. Foster was in process of recasting ARPA and reasserting DDR&E control over it.

attitude "a failing in every job I've had ... I've played public relations much too low key."[59] In those days ARPA seemed content to keep the DDR&E happy and console itself with the fact that it knew that it was doing a first rate job. There was also a certain feeling that the less Congress and the Services knew, the less friction would result and accordingly ARPA would create fewer troubles for itself and the DDR&E. Its research results, in other words, would speak for themselves. This admirable rationalization resulted in a self-spun protective cocoon based on the belief that ARPA should lie low, do good things, and eventually all the right people would find out about them. It proved to be short-sighted policy. Many outsiders interpreted this outlook simply as undue arrogance and it may actually have reinforced the critics' propensity to find fault.

An excellent example of ARPA hiding its light under a basket is its research related to penetration aids. Many in ARPA consider it a major contribution to the national defense. Even discounting for the initial high classification and limited access nature of the work, ARPA went out of its way to say very little about it. The following exchange is an excellent example of the customary ARPA approach:[60]

> A: I don't think that pen aids officially identified as such was ever more than 20 per cent of the DEFENDER budget. On the other hand, in my own personal view, which I shared with <u>few</u> people at the time, the real raison d'etre for the reentry program was pen aids. Therefore, the raison d'etre for about half of the DEFENDER program was pen aids. Therefore, I saw it mostly as a pen aids exercise at the end. Now, I shared this view with Sproull, with Ruina, with the DDR&E's, and with McNamara. I suggested it in Congressional hearings, but always in a classified session.
>
> Q: But not [stated] flat out?
>
> A: Not really flat out. But people who understood, understood immediately. They said, 'yeah, isn't it great we happen to have all the right stuff in place.' I said, 'yes, it's great.' It was a lucky accident. To a large extent, it was a lucky accident. It was turned into -- that accident was worked very hard -- it turned into a very strong policy.
>
> Q: We have been right, more or less, in inferring that pen aids probably became the dominant justification for continuing PRESS?

A: Absolutely, because while I thought it was very important to find out the infinite details of the reentry physics in order to get a laboratory, if you will, discrimination capability, I had little confidence ... that that could be fielded very effectively, for a lot of reasons.... On the other hand, I was absolutely sure that that also allowed me to understand what the other fellow would have to do to counter our attack, and boy that was worth every penny spent there.

The Presidential interest in this subject, or that of the Secretary and the DDR&E, and their explicit decision to use ARPA in this area received scant attention, much less the work itself. It is important to lay such groundwork. "Presidential issues" do not recur regularly, but if one is to have an agency available to cope with them there has to be recognition in the "down times" that the agency has performed well. ARPA did not do a good job of sustaining that understanding, nor did successive Secretaries and DDR&E's.

The "low profile" ARPA of the early 1970's carries on this policy. With direct transfer of projects rated so highly, ARPA also believes that it must be very careful to minimize the NIH (not invented here) factor which can inhibit Service acceptance of ARPA results. Self-effacement is considered essential to achieving that objective. ARPA's gradual addition of intelligence-related projects reinforces this policy. Indeed ARPA has consistently indulged a propensity to engage in intelligence-related R&D from the early work on reconnaissance satellites to the present day. Such work serves as sort of a surrogate for "Presidential issues" because the aura of secrecy involved implies significance; often comes with a built-in user and relevance justification; minimizes review requirements; and provides an additional rationale for keeping a "low profile." On the other hand, ARPA has consistently had management problems with such work because access limitations do impede adequate peer review.

In summary, in its attempt to survive, ARPA has simply made the "low key" habitual. As Lukasik puts it: "I don't believe, deep down, then and now, that ARPA should advertise."[61]

Related to the issue of establishing its record, we return to the observation that ARPA has not stimulated a broad following or clientele in the scientific community, despite its reputation for flexibility, willingness to support far-out ideas, commitment to long-term funding of basic research (for a time), and skill in managing advanced research. ARPA has its loyal adherents in specific fields, e.g., advanced computer science and technology and substantial segments of the missile defense R&D community, but somehow these have tended to remain pockets of support rather than becoming the basis for strong backing across the board. The early feuding with PSAC and the President's Science Adviser cost the Agency dearly, creating a level of suspicion or disappointment that never was overcome. Ruina helped immensely with his personal rapport with the scientific elite, but no serious institutional linkage between it and ARPA emerged. Sproull maintained the level of civility attained during the Ruina periods. Dr. Ruina believes that ARPA failed to develop strong vocal backing among many of the researchers it supported because the money was filtered through agents (who were there before ARPA and would be afterwards) and because they regarded ARPA program managers, ARPA Directors, and perhaps ARPA itself as transitory. Thus rather than run the risk of offending the established bureaucracy, they tended to avoid testimonials.

ARPA certainly passed the stage of being transitory and it developed a record of not being cavalier in its willingness to support good programs; however, by that time the highly politicized issues that divided DOD and many in the scientific community -- ballistic missile defense systems deployment, the Vietnam War, arms control and disarmament, etc., plus the great debate regarding the role of science and technology in society generally -- were at work, and tended to swamp any attempts at unraveling a factor as specific as ARPA. Suffice it to say that the advanced research agency stimulated by a scientific elite intent on modernizing and educating the military somehow failed to forge or sustain a lasting link with its progenitors of the scope and depth which might have been anticipated.

By and large, our respondents and the written record portray a most inadequate performance in explaining ARPA. This is most unusual for an agency with ARPA's budget levels. The complexity of much of its subject matter undoubtedly complicates explanation. Greater exposure would likewise generate criticism and increase the vulnerability of some programs or projects, although that seems unlikely after the events of 1968 and subsequent years. Indeed those events tend to confirm the necessity of presenting an accurate and balanced story.

It remains to be seen whether the early-1970's ARPA, based on relevance, transfer, small projects, and the low profile will succeed in the sense of communicating satisfactorily with the higher authorities to which it must respond. The Presidential issue assignments no longer exist. The case seems to rest with the appeal of presenting an ARPA geared increasingly to Service and to intelligence-related requirements.

THE READER'S CHOICE

In seeking a final assessment of ARPA over its various periods, the observer is driven back to personal values and to highly subjective judgments concerning the Agency's influence on science and technology and on the military establishment. Virtually every Director of ARPA and every major program manager has been both praised and damned. The flash and melodrama of Roy Johnson's grand battles over space programs were to many respondents the peak of the Agency's existence. To others, those days were all motion and little substance. Dr. Ruina's emphasis on research quality and broad support for technological advance was to many, especially participants in that period, little short of heroic -- the essence of what has made ARPA unique. To others, the Ruina approach was the height of folly, leading to severe questioning of the legitimacy of the ARPA mission and ultimately to near-cancellation of the Agency; to these observers, Rechtin's vigorous insistence on transfer and Defense relevance and Lukasik's development of a solid base of Service relationships resurrected the Agency and endowed it with a viable role. To some, however, Dr. Herzfeld's proud defense of a muscular, independent, free-wheeling ARPA, sensitive to the major policy issues of the day, represented the last valiant attempt to maintain an Agency that could "make a difference" in the Defense establishment. Yet to still another group the balanced Agency management and spectacular technical project successes of Dr. Sproull's period were the high point of the ARPA story.

On programs, as with Directors, the observer is given a wide range of choice. Was VELA the hidden ingredient essential to the achievement of the limited and threshold test ban agreements, or did its adjustments to the Defense establishment compromise the nation's ability to conclude a truly comprehensive treaty? Was AGILE a "glorious failure," a voice in the wilderness which, if heard, could have moderated the traumas of Southeast Asia; or was AGILE merely a symptom of Defense Department and ARPA confusion, ineptitude and inability to recognize or admit that they could not cope with a problem? Did ARPA's broad institutional support for materials science, information processing technology, seismology, and other fields fundamentally strengthen the nation's scientific infrastructure, or did it simply postpone the evolution of a rational Federal program of support to science? Was DEFENDER at the core of the development of modern strategic offensive and defensive technology, or was it an expensive luxury providing unnecessary confirmation of the obvious and a scientific and technological hobby shop for developments never to be deployed? The list could be continued indefinitely.

What is in the end most unique about ARPA, taking an historical view, is that there is no other technology-oriented agency in Washington to match it in the pretentiousness of its claims, the exposure of its work to serious criticism and the colorfulness of its style.

The maximist view of ARPA credits the Agency with setting the course for the evolution of U. S. space technology, strategic defensive technology, strategic offensive technology, and the future directions of tactical technology and possibly naval warfare. In other words, outspoken ARPA advocates sometimes claim that the Agency has established the key technological parameters for the Defense Department and NASA. In addition, the maximist view gives the Agency credit for establishing the cutting edge of materials science, computer science, radar technology, seismology and geophysics, laser technology, quantitative political science, and other areas, plus intervening at crucial times in aspects of radio astronomy, energy conversion, propellant chemistry, climatology, atmospheric physics, and many other fields.

The critics, on the other hand, can see expensive monuments to failure or to irrelevance all over the landscape: the giant ILLIAC IV computer, the sprawling LASA array in Montana, the Arecibo dish, many and varied radars (e.g., PINCUSHION), an abandoned SATURN clustered rocket technology, indirectly a non-operational Safeguard BMD installation, and many others. This is not to mention the many abandoned programs, projects and endless study efforts not necessarily resulting in obvious hardware or results, ranging from the counterinsurgency field units, through far-fetched systems and sensitivity studies to aborted university-industry materials "coupling" programs.

As to colorfulness, there is no other agency that could match a repertoire of investigations including a nuclear bomb-propelled rocket, a "mechanical elephant," plans to orbit millions of bee-bees for BMD purposes, man-computer communications via brain waves, laser and charged particle weapons, and a multi-million dollar program sold through a diagram of a Greek temple. And these are not necessarily even the most exotic entries in ARPA's book of memorabilia. This is an Agency which has designed both super-acceleration rockets and balloons tied to a cable. It is also no surprise to find that Evel Knievel's steam-propelled rocket motorcycle was designed by an ARPA alumnus.

In the end, the reader is left to search for his own net assessment of ARPA's ultimate value, sorting amongst the triumphs, failures, disappointments, and the flaky according to his own standards and expectations. For our part, it does not appear possible to measure conclusively ARPA's influence on the Defense establishment and broad areas of science and technology. The far more exciting proposition is to consider what such an institution might properly be charged to do in the future. If there is a case for an ARPA, it must be because those in authority conclude that the nation and the Department of Defense feel the need, paraphrasing Ruina's words, for a place "that's for fun, not to make a living."

CHAPTER X: FOOTNOTES

1. Discussion with Dr. E. Rechtin, December 7, 1974.
2. Discussion with Dr. H. F. York, April 4, 1975.
3. *Ibid.*
4. Discussion with Dr. R. L. Sproull, May 29, 1975.
5. Discussion with Dr. H. F. York, April 4, 1975.
6. Discussion with Brig. Gen. C. A. Young, Jr., June 11, 1974. Col. Dent Lay (discussion, June 17, 1975) is very strong on this point.
7. Discussion with Dr. R. L. Sproull, May 29, 1975.
8. Discussion with Dr. S. J. Lukasik, May 28-29, 1975.
9. Discussion with Dr. R. Holbrook, July 10, 1975.
10. Unattributed study interview.
11. Discussion with Dr. S. J. Lukasik, May 28-29, 1975.
12. Discussion with Dr. R. L. Sproull, May 29, 1975.
13. *Ibid.*
14. Discussion with Dr. E. Rechtin, July 7, 1975.
15. Discussion with Dr. J. P. Ruina, June 26, 1975.
16. Discussion with Dr. J. Foster, Jr., July 9, 1975.
17. *Ibid.*
18. Discussion with Dr. R. A. Frosch, October 31, 1975.
19. *Ibid.*
20. Discussion with Dr. R. L. Sproull, May 29, 1975.
21. Discussion with Dr. J. Foster, Jr., July 9, 1975.
22. Discussion with Dr. R. L. Sproull, May 29, 1975.
23. Discussion with Dr. S. J. Lukasik, May 28-29, 1975.

24. Letter from Dr. J. R. Killian, Jr. to Lee W. Huff, June 4, 1975.

25. Discussion with Dr. J. P. Ruina, June 26, 1975.

26. Ibid.

27. Discussion with Dr. C. M. Herzfeld, September 17, 1975.

28. Ibid.

29. Discussion with Dr. R. L. Sproull, May 29, 1975.

30. Vincent Davis, The Politics of Innovation: Patterns in Navy Cases, Monograph Series in World Affairs, Vol. 4 (3), University of Denver, 1966-67.

31. Discussion with Dr. E. Rechtin, December 7, 1975.

32. Ibid.

33. Discussion with Dr. H. F. York, April 4, 1975.

34. Discussion with Dr. R. L. Sproull, May 29, 1975.

35. Ibid.

36. Discussion with Dr. J. P. Ruina, June 26, 1975.

37. Discussion with Dr. E. Rechtin, December 7, 1974.

38. Discussion with Dr. E. Rechtin, July 7, 1975.

39. Discussion with Dr. S. J. Lukasik, May 28-29, 1975.

40. Discussion with Dr. J. Foster, Jr., July 9, 1975.

41. Discussion with Dr. J. R. Killian, Jr., May 8, 1975.

42. Discussion with Dr. J. P. Ruina, June 26, 1975.

43. Discussion with Lt. Gen. A. W. Betts, April 7, 1975.

44. Discussion with Dr. C. M. Herzfeld, September 17, 1975.

45. Discussion with Dr. J. Foster, Jr., July 9, 1975.

46. Ibid.

47. Discussion with Dr. S. J. Lukasik, May 28-29, 1975.
48. Discussion with Dr. L. Roberts, April 23, 1974.
49. Discussion with Dr. J. Foster, Jr., July 9, 1975.
50. Discussion with Dr. J. P. Ruina, June 26, 1975.
51. Discussion with Dr. R. L. Sproull, May 29, 1975.
52. <u>Ibid</u>.
53. Discussion with Lt. Gen. A. W. Betts, April 7, 1975.
54. Discussion with Dr. C. M. Herzfeld, September 17, 1975.
55. Discussion with Dr. J. P. Ruina, June 27, 1975.
56. Unattributed study interview.
57. Discussion with Dr. R. L. Sproull, May 29, 1975.
58. Discussion with W. H. Godel, June 18, 1975.
59. Discussion with Dr. J. P. Ruina, June 26, 1975.
60. Discussion with Dr. C. M. Herzfeld, May 7, 1975.
61. Discussion with Dr. S. J. Lukasik, May 28-29, 1975.

APPENDIX A

ARPA FUNDING HISTORY

THROUGH FISCAL YEAR 1975

The following funding figures are based on an internal budget table prepared by the Defense Advanced Research Projects Agency, dated November 4, 1974.

ARPA FUNDING HISTORY
(Dollars in Millions)

scal ear	Amount Requested	(NOA) Amount Appropriated	Program Approved by Congress	Congressional Cut	Program at End of Fiscal Year
958	-	-	-	-	31.5
959	520.0	520.0	520.0	-0-	485.8
960	455.0	455.0	455.0	-0-	340.9
961	215.0	215.0	215.0	-0-	259.6
962	186.0	186.0	186.0	-0-	250.7
963	257.0	250.0	250.0	- 7.0	254.8
964	280.0	274.6	274.6	- 5.4	283.2
965	283.4	278.1	278.1	- 5.3	275.5
966	277.0	274.3	274.3	- 2.7	273.9
967	262.9	255.9[c]	262.9[c]	-0-	278.5
968	254.1	248.7	248.7	- 5.4	228.3
969	244.7	233.2	233.2	-11.5	200.4[a]
970	238.1	212.1	212.1	-26.0	216.0
971	222.7	209.0	209.0	-13.7	209.0
972	228.0	206.5[b]	209.8[b]	-18.2	212.4
973	226.7	199.7	199.7	-27.0	199.7
974	210.5	194.2	194.2	-16.3	194.3
975	216.8	202.3	202.3	-14.5	202.3

<u>Footnotes to Table:</u>

Prior to FY 1963 ARPA was not on a program year basis, and all uncommitted funds as of June 30 were included in following year program totals.

[a] $38.0 million transferred to Dept. of Army for ABMDA Program.

[b] In FY 1972 Congress approved a program $3.3 million in excess of NOA. $3.3 million was obtained by reprogramming FY 1971 & prior year funds into FY 1972.

[c] In FY 1967 Congress approved a program $7.0 million in excess of NOA. The $7.0 million was supposed to be a reimbursement from Dept. of A. F. for Atlas boosters.

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